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EFFECTS OF CULTIVATION AND CROPPING ON THE CHEMICAL COMPOSITION OF SOME WESTERN CANADA PRAIRIE SOILS

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Department of Soils

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TABLE OF CONTENTS

Page

Introduction 1

Review of Literature 2

Experimental Procedure 8

Soil Sampling 8

Methods of Analysis 11

Experimental Results 12

Soil Variability, Sampling and Analytical Errors 26

Total Nitrogen Results 28

Black Soils 29

Dark Brown Soils 37

Brown Soils 42

Gray Transition Soils 47

Gray Soils 49

The Effect of Length of Time of Cultivation on Nitrogen Loss 53

The Effect of Soil Class on Loss of Nitrogen 54

The Effect of Cropping Systems on Nitrogen Gains or Losses 55

Summary of Nitrogen Determinations 58

Organic Carbon Results 60

Black Soils 60

Dark Brown Soils 66

Brown Soils 71

Gray Transition Soils 76

TABLE OF CONTENTS (Continued)

Page

Gray Soils 78

The Relation Between Years of Cultivation and Loss of Carbon and Organic Matter 81

The Effect of Soil Class on Loss of Organic Carbon and Organic Matter 82

The Effect of Cropping Systems on Loss of Organic Carbon and Organic Matter 84

Summary of Carbon Determinations 86

The C:N Ratios of Virgin and Cultivated Soils .. 88

Total Phosphorus Results 93

Black Soils 93

Dark Brown Soils 98

Brown Soils 99

Gray Wooded Soils 102

Summary of Phosphorus Determinations 105

Easily Soluble Phosphorus Determinations 106

Black Soils 106

Dark Brown Soils 111

Brown Soils 112

Gray Soils 115

Summary of Easily Soluble Phosphorus Determinations 117

Nitrification Results 118

Summary of Nitrification Studies 125

Potassium Results 126

Discussion of Results 129

TABLE OF CONTENTS (Continued)

Page

Nitrogen 129

Crop Removal 129

Losses of Nitrogen Due to Leaching 132

Losses of Nitrogen Due to Wind and Water Erosion 133

Loss of Nitrogen in Some Volatile Form 134

Organic Carbon 135

Carbon to Nitrogen Ratios 137

Total Phosphorus 138

Easily Soluble Phosphorus 139

Nitrification 140

Potassium 142

Summary 144

Acknowledgment 148

References 149

Map - Locations of Major Soil Zones 10

Graphs (1-18) - Nitrifying Power of Virgin and Cultivated Soil 120

EFFECTS OF CULTIVATION AND CROPPING ON THE CHEMICAL COMPOSITION OF SOME WESTERN CANADA PRAIRIE SOILS

A. C. Caldwell

INTRODUCTION

Soil exhaustion has become a major agricultural problem in many countries where cultivation and cropping have been carried on for many years. The prairie soils of western Canada have been settled only a comparatively short time, the main tide of settlement in Alberta, for instance, having occurred in the early years following 1900. Climatic conditions and soil type have proved admirable for the growth of small grains, and western Canada quickly developed into one of the major producers and exporters of excellent quality spring wheat. Farming practices and cropping systems employed by the farmer have been very similar over wide areas, and consist largely of a grain and fallow type, claimed by many to be wasteful and extravagant in the extreme. The grains are harvested and sold off the farm, the straw very often being sold or burned, and in consequence nothing is returned to the land.

In any system of permanent agriculture, one of the first concerns should be the maintenance of soil fertility. If soil exhaustion and deterioration is tak~~en~~ing place evidence

should be gathered as to the nature and extent of plant food losses. Decrease in fertility may be shown by a decline in yields. A chemical analysis of the soil may show depletion in elements essential for plant growth. The latter method has been employed in this study in an attempt to determine by chemical analysis of some cropped and virgin soils, what effect the present methods of farming have had on some total and easily soluble plant foods.

REVIEW OF LITERATURE

Decline in Yields. The evidence from Rothamsted and Woburn reviewed by Williams (38) indicates a decline in yield of grain grown continuously without treatment.

Rothamsted continuous wheat declined 42 per cent. in 60 years.
" " barley " 58 " " " 50 "
Woburn " wheat " 47 " " " 30 "
" " barley " 63 " " " 30 "

Experiments at Ohio, Missouri, Illinois and Pennsylvania also demonstrate decline in yields of crop grown continuously and in rotation.

Ohio continuous wheat declined 27 per cent. in 20 years.
" " oats " 29 " " " " "
" " corn " 57 " " " " "

Missouri continuous wheat declined 20 per cent. in 20 years.
" " corn " 41 " " " " "
" " oats gained 16 " " " " "
Illinois " corn declined 30 " " " " "
Ohio 5 year rotation without fertilizer treatment declined 25 " " " " "

Ohio 3 year rotation of corn, oats and clover

Corn, without fertilizer treatment declined 45 per cent. in 12 years.

Oats, without fertilizer treatment declined 28 " " " " "

Clover, without fertilizer treatment declined 65 " " " " "

Pennsylvania, 4 year rotation, without treatment production declined 49 per cent in 32 years.

Gain or Loss of Plant Foods

Nitrogen analyses of various fields at Rothamsted show evidence of loss of this important plant food.

Warington (34) reports a difference in nitrogen content between arable soil and old pasture soil of 0.125 per cent., or 2,336 pounds of nitrogen per acre, sampled to a depth of 9 inches. Also comparing arable soil with pastures of various ages, the percentage of nitrogen increased with years under grass. An 8 year old pasture contained 0.011 per cent. more nitrogen than the arable soil, and a 30 year old pasture 0.1 per cent. more (35).

Hall (9) compared the nitrogen content of a plot manured for 50 years with one unmanured. The former showed a loss of 5,670 pounds of nitrogen. Hall (10) reports the analysis of lands in Broadbalk and Geescroft allowed to run wild for 22 years. The former gained 2200 pounds of nitrogen, the latter 1400.

In the United States much work has been done on an estimation of the gain or loss of plant foods as a result of cultivation and cropping. Two main lines of approach have been used in attacking the problem.

(1) A comparison of cultivated soil and nearby virgin sod, as they occur naturally in the field.

(2) A determination of the effects of cultivation and cropping on soils under control conditions, in the field or in the laboratory.

Since the work has been so widespread results reported cover various types of cropping systems and soil treatments under various conditions of rainfall and climate. Most attention has been placed on the surface soil, but in some cases lower depths have been analyzed as well.

Soil nitrogen, perhaps more than any other essential plant food, has been the object of research and discussion for many years. Because of its importance in the soil, and since it is in many cases none too plentiful to begin with, studies on the effect of cultivation and cropping usually

include an estimation of nitrogen gain or loss.

Losses of nitrogen, from great to small amounts, have been reported by numerous workers: Alway, Nebraska (2), Snyder, Minnesota (26), Whitson, Stoddard and MacLeod, Wisconsin (37), Jones and Yates, Oregon (13), Russel, Nebraska (21), Daniel and Langham, Oklahoma (6), Bracken and Greaves, Utah (4), Swanson and Latshaw, Kansas (31), Dorman, Michigan (7). Losses of nitrogen, in varying amounts, depending on the treatment, were found in some cultivated soils under control conditions: Gainey, Sewell and Latshaw, Kansas (8), Lyon, Cornell (16), Russel, Nebraska (21), Lipman and Blair, New Jersey (15), Salter and Green, Ohio (22), Stewart, California (27), Wright, Washington, D.C. (39).

Closely associated with nitrogen in the soil, and important as well, because of its physical and chemical action, is organic carbon sometimes converted into and reported as organic matter. Carbon losses as a result of cultivation have been shown by the following: Alway (2), Jones and Yates (13), Russel (21), Daniel and Langham (6), Bracken and Greaves (4), Swanson and Latshaw (31).

Though most of the work reviewed points towards a reduction of nitrogen and carbon as a result of cultivation and cropping, not all workers found this to be the case. In some instances no change or even a gain in nitrogen and carbon has resulted. Stewart and Hirst (29) report no change in nitrogen and carbon. Wheeting, Western Washington (36) found

a gain in cultivated soil of both nitrogen and carbon. Jordan, New Mexico (14) reports that alfalfa on irrigated land for more than 2 or 3 years increased the carbon and nitrogen content.

Some controlled experiments reviewed showed from no loss to a gain in nitrogen, depending on the treatment: Lyon (16), Salter and Green (22), Powers and Lewis, Oregon (19). Some workers report a gain in carbon content: Russel (21), Lipman and Blair (15), Powers and Lewis (19).

Only a few reports among the number reviewed discuss the effects of cultivation and cropping on plant nutrients other than nitrogen and carbon. Swanson (30) compared cultivated and virgin soils as to their N, C, P, K and Ca content and found appreciable losses in nitrogen and carbon only. Dorman (7) made a very complete analysis of virgin and cultivated soils to the plowing depth, about 6 inches. Total chemical analyses for Si, Fe, Al, Ca, Mg, K, Na, P, and N, showed consistent differences in nitrogen content only.

Stewart (27), in a controlled experiment, reports a 35 per cent. decline in production of 7 silty clay loams and 7 fine sandy loams, cropped for 7 years. No depletion in plant foods could be shown by a total chemical analysis.

Swanson and Miller, Kansas (32) analyzed cultivated and virgin soils for sulphur content and found an average loss from surface, subsurface and subsoil of about 40 per cent.

Significant differences in exchangeable bases could

not be found as a result of cropping: Dorman (7), Powers and Lewis (19).

A reduction of water soluble salts in cultivated soils was shown by Millar, Wisconsin (18), and Stewart (27). On the other hand Powers and Lewis (19), could find no such reduction as a result of cropping.

Dorman (7) found available phosphorus to be very low in both virgin and cultivated soils, and no consistent difference in favor of one or the other.

Stewart (27) found that water soluble phosphorus was lower in 5 out of 7 sandy loams. No significant difference in water soluble phosphorus was reported by Millar (18), and Powers and Lewis (19).

A narrowing of the C:N ratio was cited in three cases: Alway (2), Wheeting (36), Powers and Lewis (19).

The nitrate supplying power of the cultivated soil seemed to be greater: Wheeting (36), Powers and Lewis (19).

In Canada, Shutt (25) compared virgin and cultivated soils at two locations in the West and found decreases of 25 per cent. and 30 per cent. of the original nitrogen content. Other analyses of soils cropped in a rotation led to the conclusion that the nitrogen content had been maintained and in certain instances materially increased.

Hansen (11) in comparing 6 samples of virgin and cultivated, Saskatchewan, soils found an average loss of 21

per cent. of the nitrogen, and a computed loss of 1/5 of the original organic matter content.

EXPERIMENTAL PROCEDURE

Soil Sampling

Thirty-two sets of soil samples were collected for this investigation at points in Alberta and Saskatchewan. An attempt was made to collect about the same number of samples from each of the major soil zones into which Alberta and Saskatchewan are divided. The three principle soil zones are the black park or prairie, brown prairie, and gray wooded. Between these major areas lie transition zones of small to large extent. Between the black and gray wooded zones are small areas of transitional soil. Between the black and brown zones lies a transition zone, intermediate in properties between the two, but so large in area that it is often classed as a separate zone, the dark brown. It was so treated in this work except that in the brief description of the soil zones and profiles to follow it is included in the brown zone.

In southern Alberta and Saskatchewan are the brown soils, typical prairie or short grass plains, developed under low precipitation, about 12 inches, and high evaporation.

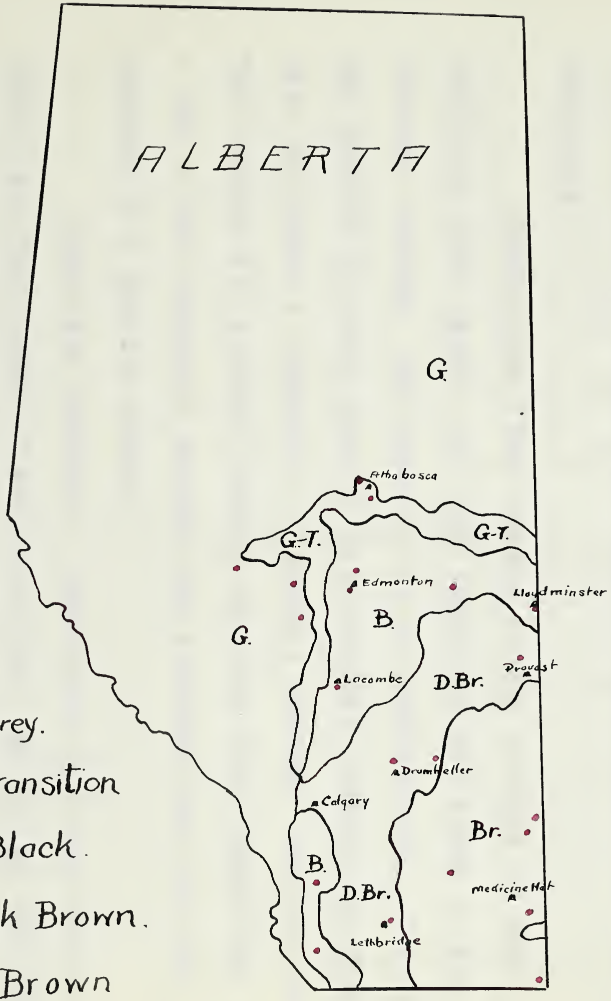
The soil is low in organic matter and characterized by relatively thin A and B horizons with the lime accumulation zone close to the surface.

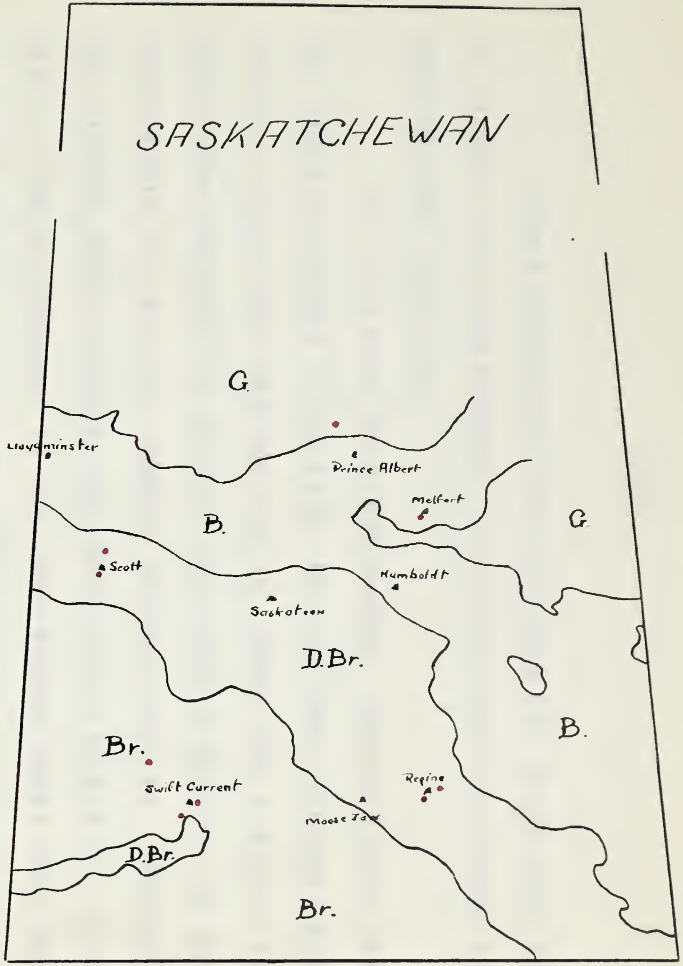
Further north lies the black soil zone. Precipitation is higher, about 16 to 19 inches, and evaporation is lower. The black parkland soils are generally characterized by a deep layer of dark colored soil, rich in organic matter, and by the presence of clumps of trees. The A_1 horizon has an average depth of about 10 inches. The B horizon is generally well developed and easily distinguished, and the B_2 or lime accumulation layer usually occurs at 2½ to 4 feet from the surface.

The gray soil zone lies to the north and west of the black zone, and is fairly heavily wooded for the most part. The rainfall varies from about 16 to 20 inches, but evaporation is low due to forest growth, so considerable leaching has taken place, indicated by the gray ashy appearance of the land when cultivated. The soil profile is characterized by a layer of leaf mold about 2 inches thick, the A_0 horizon. The A_1 and A_2 horizons then comprise about 8 to 10 inches of grayish leached soil. The B_1 is slightly darker in color and usually heavy in structure, while the B_2 or lime layer, is seldom found closer to the surface than 3 to 6 feet.

A more detailed description of typical Alberta soil profiles from the various zones has been given by Wyatt and Newton (40) elsewhere.

SKETCH MAPS SHOWING LOCATIONS OF MAJOR SOIL ZONES





LEGEND.

G.	Grey.
G-T.	Grey Transition
B.	Black.
D.Br.	Dark Brown.
Br.	Brown
∴	Location of Samples.

The accompanying map outlines the major soil zones in Alberta and Saskatchewan, with the locations marked where samples were obtained.

For the most part the samples obtained were taken in the field according to profile, but in some instances the surface horizon was divided and in others two and part of a third were combined to make up the plowing depth. In several black soils the deep A_1 organic matter layer was divided and the plowing depth taken as one sample, while the A_0, A_1 and part of the A_2 horizons of the gray wooded soils were combined to have a sample corresponding to the plowing depth of the cultivated soil in which the profile development had been destroyed.

During the first summer single samples of each duplicate were taken, but such variation was found in the nitrogen results, particularly in the surface soil, that it was decided the next year to take several borings and make each duplicate a composite of several borings (usually 10). That summer all surface samples obtained were composites, and a few of the locations sampled the previous year were re-sampled in a similar manner.

Duplicate samples of cultivated soil and nearby virgin sod were taken at each location. As far as possible, within the district sampled, an attempt was made to get samples of soil that had been cultivated for the greatest length of time, and samples that had never been fertilized

or artifically treated in any way except for cultivation and cropping. At several experimental stations plots were sampled that had grown crops in rotation, or an irrigated land, where fertilizers had not been applied. One major difficulty experienced, particularly in the south of the provinces, was locating lands that had not been subject to drifting. Drifted places were avoided as much as possible, but there is no doubt that some of the samples obtained have at one time or another been subject to a certain amount of loss of surface soil through wind erosion.

Sod samples were taken from pastures, road sides and road cuts for the most part, and here again drift was avoided.

Soil classes were classified by moistening the soil and rubbing in the palm of the hand, and an attempt was made to distribute the samples among the princip~~le~~al soil classes.

If the soil were not too dry and gravel or rocks did not interfere, a 2 inch soil auger was used; otherwise the samples were obtained with a spade.

Methods of Analysis

After most of the larger stones and heavier debris had been removed the samples were air dried in the laboratory and then ground as finely as possible in a Braun pulverizer.

Total nitrogen was determined by the familiar

Kjeldahl Gunning method.

Organic carbon was determined by Schollenberger's (23, 24) chromic acid reduction method, as modified by Allison (1). Organic matter was computed from organic carbon by multiplying by 1.724.

After a $Mg(NO_3)_2$ fusion of the soil and precipitation of phosphorus as ammonium phospho molybdate total phosphorus was determined volumetrically.

After fusion in silica crucibles total potassium was determined by the platinic chloride method.

Truog's (33) colorimetric method was used in the easily soluble phosphorus determination.

Estimation of nitrates in incubated samples was made by the colorimetric phenol-di-sulphonic method (Harper (12)).

EXPERIMENTAL RESULTS

Table I presents the total nitrogen, organic carbon, and phosphorus in per cent., and the easily soluble phosphorus in parts per million, of all samples analyzed for these elements. Total potassium was run on only a few samples and the results are reported in a separate table. The results from nitrification studies are also placed in a separate table, as they do not lend themselves to the form of Table I.

Table I. Total nitrogen, carbon and phosphorus in per cent. and easily soluble phosphorus in P.P.M.

Sample No.	Location	Zone & class		Virgin or cult.	Depth in inches	N %	C %	P %	Easily soluble P P.P.M.
1	Brooks	#Lt.Br.	xF.S.L.	Sod	0-9	.158	2.22	.053	6.4
2	"	"	"	"	9-16	.062	0.89	.044	6.0
3	"	"	"	"	16-36	.045	0.55		
4	"	"	L.	"	36-42	.024			
5	"	"	F.S.L.	"	0-9	.159	2.14	.064	Trace
6	"	"	"	"	9-16	.063	0.73	.042	5.6
7	"	"	"	"	16-36	.033	0.59		
8	"	"	L.	"	36-42	.039			
9	"	"	F.S.L.	Cult.	0-9	.105	1.35	.036	Trace
10	"	"	"	"	9-16	.080	0.98	.045	"
11	"	"	"	"	16-36	.047	0.64		
12	"	"	L.	"	36-42	.042			
13	"	"	F.S.L.	"	0 -9	.097	1.18	.041	4.0
14	"	"	"	"	9-16	.069	0.69	.039	5.2
15	"	"	"	"	16-36	.047	0.50		
16	"	"	L.	"	36-42	.031			
17	Hand Hills	Dk.Br.	L.	Sod	0-8	.207	2.65	.063	Trace
18		"	C.L.	"	8-14	.102	1.35	.041	3.6
19	"	"	C.	"	14-22	.057			
20	"	"	L.	"	0-8	.234	3.10	.053	3.6
21	"	"	C.L.	"	8-14	.110	1.33	.042	4.4
22	"	"	C.	"	14-22	.065			
23	"	"	L.	Cult.	0-6	.239	3.16	.052	6.0
24	"	"	C.L.	"	6-12	.149	1.60	.062	4.0
25	"	"	C.	"	12-20	.070	0.84		
26	"	"	L.	"	0-8	.207	2.69	.065	5.2
27	"	"	C.L.	"	8-14	.119	1.34	.054	8.0
28	"	"	C.	"	14-22	.078			
29	Acadia Valley	Lt.Br.	C.	Sod	0-6	.156	1.98	.072	74.4
31		"	"	"	6-8	.099	1.04	.066	88.0
32	"	"	"	"	0-6	.147	1.57	.067	140.3
34	"	"	"	"	6-8	.107	1.04	.063	89.8
35	"	"	"	Cult.	0-6	.153	1.69	.065	70.4
37	"	"	"	"	6-8	.101	0.93	.062	49.6
38	"	"	"	"	0-6	.156	1.71	.075	65.6
40	"	"	"	"	6-8	.096	0.99	.066	40.0

# Bl. - Black
Dk.Br. - Dark Brown
Br. - Brown
Tr.Gr. - Transition Gray
Gr. - Gray

x L. - Loam
Si.L. - Silt Loam
C. - Clay
C.L. - Clay Loam
F.S.L. - Fine Sandy Loam
S.L. - Sandy Loam

Table I (Continued)

Sample No.	Location	Zone & class		Virgin or cult.	Depth in inches	N %	C %	P %	Easily soluble P P.P.M.
41	Cavendish	Lt.Br.	F.S.L.	Sod	0-5	.158	2.01	.056	8.4
43	"	"	"	"	5-12	.093	1.04	.055	6.8
44	"	"	L.	"	12-20	.059			
45	"	"	F.S.L.	"	0-5	.146	1.83	.049	8.0
47	"	"	"	"	5-12	.105	1.13	.057	8.4
48	"	"	L.	"	12-20	.087			
49	"	"	F.S.L.	Cult.	0-5	.130	1.45	.052	9.6
51	"	"	"	"	5-12	.122	1.19	.058	4.8
52	"	"	L.	"	12-18	.065			
53	"	"	F.S.L.	"	0-5	.110	1.20	.057	4.0
55	"	"	"	"	5-12	.102	0.89	.058	11.2
56	"	"	L.	"	12-18	.069			
57	Swift Current	Lt.Br.	L.	Sod	0-6	.254	3.31	.069	27.6
59		"	"	"	6-18	.117	1.38	.066	6.0
60	"	"	C.	"	18-24	.080			
61	"	"	L.	"	0-6	.278	3.68	.066	30.4
63	"	"	"	"	6-18	.111	1.24	.064	11.6
64	"	"	C.	"	18-24	.104			
65	"	"	L.	Cult.	0-6	.264	3.51	.082	7.6
67	"	"	"	"	6-18	.082	0.83	.068	8.4
68	"	"	C.	"	18-24	.062			
69	"	"	L.	"	0-6	.278	3.62	.077	8.0
71	"	"	"	"	6-18	.104	1.13	.061	6.0
72	"	"	C.	"	18-24	.083			
73	Gros Ventre	Lt.Br.	L.	Sod	0-6	.295	4.14	.082	7.6
75		"	C.L.	"	6-20	.105	1.25	.072	7.2
76	"	"	C.	"	20-26	.092			
77	"	"	L.	"	0-6	.287	3.97	.091	6.8
79	"	"	C.L.	"	6-20	.116	1.23	.072	8.0
80	"	"	C.	"	20-26	.075			
81	"	"	L.	Cult.	0-6	.186	2.38	.073	4.0
83	"	"	C.L.	"	6-20	.075	0.89	.070	12.0
84	"	"	C.	"	20-26	.050			
85	"	"	L.	"	0-6	.185	2.25	.070	6.0
87	"	"	C.L.	"	6-24	.081	0.89	.073	20.8
88	"	"	C.	"	24-30	.054			
89	Manyberries	Lt.Br.	L.	Sod	0-6	.111	1.36	.060	4.8
91		"	Si.L.	"	6-14	.090	1.00	.063	9.6
92	"	"	"	"	14-20	.054			
93	"	"	L.	"	0-6	.123	1.47	.060	4.4

Table I (Continued)

Sample No.	Location	Zone & class		Virgin or cult.	Depth in inches	N %	C %	P %	Easily soluble P P.P.M.
95	Manyberries	Lt.Br.	Si.L.	Sod	6-14	.079	0.93	.055	6.0
96		"	"	"	14-20	.077			
97	"	"	L.	Cult.	0-6	.101	1.15	.054	8.4
99	"	"	Si.L.	"	6-14	.084	0.93	.059	6.8
100	"	"	"	"	14-18	.084			
101	"	"	L.	"	0-6	.090	1.00	.055	5.6
103	"	"	Si.L.	"	6-14	.086	0.88	.058	8.8
104	"	"	"	"	14-18	.044			
105	Lethbridge	Dk.Br.	Si.L.	Sod	0-5	.210	2.65	.071	15.6
107		"	"	"	5-12	.158	1.71	.062	18.0
108	"	"	"	"	12-18	.096	0.98		
109	"	"	"	"	0-5	.217	2.74	.074	19.2
111	"	"	"	"	5-12	.147	1.58	.064	24.6
112	"	"	"	"	12-18	.077	0.76		
113	"	"	"	(Cult.	0-5	.198	2.29	.075	16.0
115	"	"	"	(Rot.U	5-10	.173	1.81	.068	16.0
116	"	"	"	"	10-16	.113	1.18		
117	"	"	"	"	0-5	.192	2.21	.070	21.6
119	"	"	"	"	5-10	.168	1.77	.068	13.2
120	"	"	"	"	10-16	.126	1.33		
121	Pincher Creek	Bl.	Si.L.	Sod	0-7	.574	8.01	.119	20.2
123		"	C.	"	7-22	.153	1.72	.066	5.6
124	"	"	"	"	22-28	.069			
125	"	"	Si.L.	"	0-7	.580	7.93	.111	18.8
127	"	"	C.	"	7-22	.119	1.33	.064	11.8
128	"	"	"	"	22-28	.066			
129	"	"	Si.L.	Cult.	0-7	.399	4.91	.099	19.2
131	"	"	C.	"	7-22	.126	1.40	.055	5.2
132	"	"	"	"	22-28	.075			
133	"	"	Si.L.	"	0-7	.396	5.04	.110	16.4
135	"	"	C.	"	7-22	.150	1.63	.058	25.8
136	"	"	"	"	22-28	.080			
137	Parkland	Bl.	L.	Sod	0-6	.438	6.03	.100	20.0
139	"	"	C.L.	"	6-20	.140	1.67	.060	3.6
140	"	"	C.	"	20-26	.077			
141	"	"	L.	"	0-6	.411	5.68	.094	18.8
143	"	"	C.L.	"	6-16	.252	3.09	.068	Trace
144	"	"	C.	"	16-22	.143			
145	"	"	L.	Cult.	0-6	.267	3.39	.073	6.6
147	"	"	C.L.	"	6-14	.158	1.78	.066	5.2

Table I (Continued)

Sample No.	Location	Zone & class		Virgin or cult.	Depth in inches	N %	C %	P %	Easily soluble P P.P.M.
148	Parkland	Bl.	C.	Cult.	14-18	.095			
149	"	"	L.	"	0-6	.255	3.27	.076	8.8
151	"	"	C.L.	"	6-13	.161	1.89	.074	4.0
152	"	"	C.	"	13-18	.090			
153	Lacombe	Bl.	L.	Sod	0-6	.561	7.51	.114	8.8
155	"	"	"	"	6-15	.534	6.95	.116	5.6
156	"	"	C.L.	"	15-54	.039	0.61		
157	"	"	"	"	54-66	.017	0.30		
158	"	"	L.	"	0-6	.571	7.26	.116	13.2
160	"	"	"	"	6-15	.539	6.77	.120	8.8
161	"	"	C.	"	15-66	.041	0.62		
162	"	"	C.L.	"	66-	.056			
163	"	"	L.	(Cult.	0-6	.495	6.63	.117	20.0
165	"	"	"	(Rot. C	6-15	.408	5.36	.114	20.2
166	"	"	C.L.	"	15-66	.039	0.42		
167	"	"	L.	"	0-6	.521	6.91	.121	23.2
169	"	"	"	"	6-15	.407	5.53	.125	21.8
170	"	"	C.L.	"	15-66	.039	0.47		
171	Breton	Gr.Wd.		Sod	0-1½	.664			
172	"	"	Si.L.	"	1½-7	.072			
173	"	"	"	"	0-7	.158	2.87	.070	11.4
174	"	"	C.	"	7-60	.032	0.42	.076	7.2
175	"	"	"	"	60-70	.017			
176	"	"		"	0-1½	.564			
177	"	"	Si.L.	"	1½-7	.068			
178	"	"	"	"	0-7	.137	2.51	.081	21.2
179	"	"	C.	"	7-60	.032	0.45	.057	11.0
180	"	"	"	"	60-70	.024			
181	"	"	Si.L.	(Cult.	0-7	.087	1.31	.070	16.0
183	"	"	C.	(Plot C1	7-64	.027	0.44	.068	7.2
184	"	"	"	"	64-74	.011			
185	"	"	Si.L.	"	0-7	.081	1.32	.074	14.0
187	"	"	C.	"	7-64	.021	0.33	.058	8.0
188	"	"	"	"	64-74	.020			
189	"	"	Si.L.	Plot C3	0-7	.078	1.31	.070	16.0
191	"	"	C.	"	7-65	.029	0.40	.060	22.2
192	"	"	"	"	65-75	.020			
193	"	"	Si.L.	"	0-7	.096	1.45	.073	20.8
195	"	"	C.	"	7-65	.023	0.33	.061	21.2
196	"	"	"	"	65-75	.015			

Table I (Continued)

Sample No.	Location	Zone & class		Virgin or cult.	Depth in inches	N %	C %	P %	Easily soluble P P.P.M.
197	Fallis	Gr.Wd.		Sod	0-1½	.471			
198	"	"	Si.L.	"	1½-7	.057			
199	"	"	"	"	0-7	.123	2.47	.067	59.2
200	"	"	C.	"	7-60	.030	0.50	.061	20.0
202	"	"		"	0-1½	.672			
203	"	"	Si.L.	"	1½-7	.041			
204	"	"	"	"	0-7	.135	2.73	.070	30.0
205	"	"	C.	"	7-60	.030	0.49	.060	50.8
206	"	"	Si.L.	Cult.	0-7	.066	1.13	.057	46.4
208	"	"	"	"	7-48	.033	0.47	.055	71.2
209	"	"	C.	"	48-58	.029			
210	"	"	Si.L.	"	0-7	.069	1.13	.062	48.8
212	"	"	"	"	7-48	.030	0.41	.060	73.6
213	"	"	C.	"	48-58	.032			
214	MacKay	Gr.Wd.		Sod	0-1½	.554			
215	"	"	Si.L.	"	1½-7	.039			
216	"	"	"	"	0-7	.066	1.69	.093	51.2
217	"	"	C.	"	7-48	.030	0.42	.067	13.6
218	"	"	S.	"	48-60	.011			
219	"	"	"	"	60-70	.003			
220	"	"		"	0-1½	.740			
221	"	"	Si.L.	"	1½-7	.056			
222	"	"	"	"	0-7	.078	1.93	.098	43.2
223	"	"	C.	"	7-48	.027	0.44	.070	14.4
224	"	"	S.	"	48-60	.008			
225	"	"	"	"	60-70	.003			
226	"	"	Si.L.	(Cult.	0-7	.075	1.72	.114	84.8
228	"	"	C.	(Fert.	7-48	.033	0.52	.067	29.6
229	"	"	Si.L.	"	0-7	.075	1.54	.13	99.2
231	"	"	C.	"	7-50	.039	0.51	.074	36.8
232	"	"	Si.L.	Unfert.	0-7	.041	0.61	.083	36.8
234	"	"	"	"	0-7	.053	1.04	.080	30.4
236	Colinton	Gr.Tr.		Sod	0-2	.840			
237	"	"	Si.L.	"	2-8	.032			
238	"	"	"	"	0-8	.105	1.85	.061	9.8
239	"	"	"	"	8-13	.027	0.43	.042	5.0
240	"	"	C.	"	13-25	.035	0.53		
241	"	"		"	0-2	.672			
242	"	"	Si.L.	"	2-8	.068			
243	"	"	"	"	0-8	.140	2.46	.072	30.0
244	"	"	"	"	8-13	.039	0.67	.048	4.4
245	"	"	C.	"	13-25	.035	0.47		

Table I (Continued)

Sample No.	Location	Zone & class		Virgin or cult.	Depth in inches	N %	C %	P %	Easily soluble P P.P.M.
246	Colinton	Gr.Tr.	Si.L.	Cult.	0-6	.155	2.12	.075	15.0
248	"	"	"	"	6-9	.039-	0.61	.056	8.8
249	"	"	"	"	9-13	.013	0.26	.040	6.0
250	"	"	S.C.	"	13-25	.019	0.27		
251	"	"	Si.L.	"	0-6	.156	2.75	.075	10.2
253	"	"	"	"	6-9	.017	0.30	.048	7.0
254	"	"	"	"	9-13	.013	0.24	.044	12.6
255	"	"	S.C.	"	13-25	.020	0.31		
256	Namao	Bl.	L.	Sod	0-9	.519	7.76	.134	68.8
258	"	"	C.	"	9-15	.083	0.85	.069	43.2
259	"	"	"	"	15-36	.073	0.74		116.8
260	"	"	Si.	"	36-46	.046			
261	"	"	L.	"	0-9	.499	6.58	.128	72.0
263	"	"	C.	"	9-15	.123	1.30	.064	72.0
264	"	"	"	"	15-36	.089	0.87		115.2
265	"	"	Si.	"	36-46	.061			
266	"	"	L.	Cult.	0-9	.397	5.01	.131	83.2
268	"	"	C.	"	9-12	.093	0.93	.080	96.0
269	"	"	"	"	12-58	.062	0.66		166.4
270	"	"	"	"	58-82	.061			
271	"	"	L.	"	0-8	.375	5.02	.134	92.8
273	"	"	C.	"	8-12	.088	0.84	.071	48.6
274	"	"	"	"	12-30	.085	0.76		
275	"	"	Si.	"	30-40	.054	0.52		
276	Vegreville	Bl.	L.	Sod	0-8	.404	5.39	.139	24.8
278		"	C.L.	"	8-26	.089	1.08	.066	20.0
279	"	"	C.	"	26-32	.073			
280	"	"	L.	"	0-8	.419	5.60	.134	33.2
282	"	"	C.L.	"	8-34	.060	0.72	.070	26.4
283	"	"	C.	"	34-40	.061			
284	"	"	L.	Cult.	0-6	.435	5.31	.125	49.6
286	"	"	C.L.	"	6-26	.075	0.85	.054	27.6
287	"	"	C.	"	26-32	.036			
288	"	"	L.	"	0-6	.419	5.18	.116	35.2
290	"	"	C.L.	"	6-27	.088	0.99	.044	44.4
291	"	"	C.	"	27-33	.046			
292	Edgerton	Dk.Br.	L.	Sod	0-8	.342	4.46	.080	42.4
294	"	"	Si.L.	"	8-17	.118	1.27	.058	46.0
295	"	"	"	"	17-24	.058	0.61		
296	"	"	L.	"	0-8	.329	3.95	.087	24.8

Table I (Continued)

Sample No.	Location	Zone & class	Virgin or cult.	Depth in inches	N %	C %	P %	Easily soluble P P.P.M.
298	Edgerton	Dk.Br. Si.L.	Sod	8-21	.110	1.30	.062	24.0
299	"	" "	"	21-27	.065			
300	"	" L.	Cult.	0-8	.290	3.18	.081	85.6
301	"	" Si.L.	"	8-20	.110	1.14	.070	51.6
302	"	" "	"	20-26	.069			
303	"	" L.	"	0-8	.322	3.65	.086	80.0
305	"	" Si.L.	"	8-20	.126	1.16	.064	53.6
306	"	" "	"	20-26	.067			
307	Edmonton	Bl. L.	Sod	0-7	.814	9.84	.136	46.4
309	"	" Si.L.	"	7-18	.416	4.83	.102	56.0
310	"	" C.	"	18-46	.124	1.18		
311	"	" C.L.	"	46-70	.056			
312	"	" L.	"	0-7	.814	10.05	.146	120.0
314	"	" Si.L.	"	7-18	.320	3.50	.110	37.2
315	"	" C.	"	18-46	.081	0.76		
316	"	" C.L.	"	46-70	.060			
317	"	" L.	(Cult.	0-7	.697	8.66	.136	43.2
319	"	" Si.L.	(Plot Al	7-17	.545	6.70	.125	38.3
320	"	" C.	"	17-42	.108	1.34		
321	"	" L.	"	0-7	.701	8.47	.126	38.3
323	"	" Si.L.	"	7-17	.544	6.52	.114	28.0
324	"	" C.	"	17-42	.121	1.20		
325	Grosmont	Gr.Tr.	Sod	0-2	.580			
326	"	" Lt.Si.L.	"	2-8	.076			
327	"	" "	"	0-8	.135	1.84		
328	"	" C.L.	"	8-20	.064	0.43		
329	"	" "	"	20-48	.051			
330	"	"	"	0-2	.720			
331	"	" Lt.Si.L.	"	2-8	.090			
332	"	" "	"	0-8	.139	1.91		
333	"	" C.L.	"	8-20	.060	0.54		
334	"	" Lt.Si.L.	Cult.	0-8	.134	1.62		
335	"	" "	"	8-20	.066	0.54		
336	"	" "	"	0-8	.135	1.59		
337	"	" "	"	8-20	.054	0.43		
338	Lloydminster	Bl. L.	Sod	0-5	.411	5.33		
339		" Si.L.	"	5-11	.059	0.70		
340	"	" C.L.	"	11-33	.042	0.47		
341	"	" "	"	33-39	.023			
342	"	" L.	"	0-5	.414	5.50		

Table I (Continued)

Sample No.	Location	Zone & class		Virgin or cult.	Depth in inches	N %	C %	P %	Easily soluble P P.P.M.
343	Lloydminster	Bl.	Si.L.	Sod	5-11	.090	1.11		
344		"	C.L.	"	11-33	.042	0.55		
345	"	"	L.	Cult.	0-7	.396	5.03		
346	"	"	Si.L.	"	7-11	.114	1.31		
347	"	"	C.L.	"	11-30	.082	0.92		
348	"	"	L.	"	0-7	.402	5.11		
349	"	"	Si.L.	"	7-11	.160	1.88		
350	"	"	C.L.	"	11-28	.060	0.77		
351	Scott	Dk.Br.	L.	Sod	0-7	.240	3.09		
352	"	"	Si.L.	"	7-14	.085	1.02		
353	"	"	C.L.	"	14-20	.056			
354	"	"	L.	"	0-7	.257	3.24		
355	"	"	Si.L.	"	7-14	.091	1.11		
356	"	"	C.L.	"	14-20	.062			
357	"	"	L.	(Cult.	0-7	.247	3.18		
358	"	"	Si.L.	(Rot. D	7-14	.094	1.12		
359	"	"	L.	"	0-7	.253	3.20		
360	"	"	Si.L.	"	7-14	.085	0.94		
361	Cutknife	Dk.Br.	L.	Sod	0-7	.337	4.48		
362	"	"	Si.L.	"	7-22	.087	1.09		
363	"	"	C.L.	"	22-28	.033			
364	"	"	L.	"	0-7	.335	4.51		
365	"	"	Si.L.	"	7-28	.068	0.87		
366	"	"	C.L.	"	28-34	.027			
367	"	"	L.	Cult.	0-7	.242	3.02		
368	"	"	Si.L.	"	7-26	.063	0.84		
369	"	"	L.	"	0-7	.241	3.08		
370	"	"	Si.L.	"	7-22	.063	0.81		
371	Tweedsmuir	Gr.Wd.	F.S.L.	Sod	0-7	.115	2.30		
372		"	S.L.	"	7-36	.012	0.18		
373	"	"	C.	"	36-42	.027			
374	"	"	F.S.L.	"	0-7	.109	2.31		
375	"	"	S.L.	"	7-36	.010	0.20		
376	"	"	C.	"	36-42	.024			
377	"	"	F.S.L.	Cult.	0-7	.079	1.63		
378	"	"	S.L.	"	7-36	.010	0.22		
379	"	"	F.S.L.	"	0-7	.079	1.72		
380	"	"	S.L.	"	7-36	.007	0.19		

Table I (Continued)

Sample No.	Location	Zone & class		Virgin or cult.	Depth in inches	N %	C %	P %	Easily soluble P P.P.M.
381	Melfort	Bl.	L.	Sod	0-7	.648	8.41		
382	"	"	Si.L.	"	7-14	.347	4.43		
383	"	"	C.L.	"	14-24	.108	1.31		
384	"	"	C.	"	24-32	.062			
385	"	"	L.	"	0-7	.643	8.30		
386	"	"	Si.L.	"	7-14	.293	3.68		
387	"	"	C.L.	"	14-24	.096	1.19		
388	"	"	C.	"	24-32	.057			
389	"	"	L.	Cult.	0-7	.541	6.96		
390	"	"	Si.L.	"	7-14	.361	4.38		
391	"	"	C.L.	"	14-24	.168	1.95		
392	"	"	L.	"	0-7	.548	7.08		
393	"	"	Si.L.	"	7-14	.485	5.60		
394	"	"	C.L.	"	14-24	.142	1.61		
395	Regina - South	Dk.Br.	C.	Sod	0-6	.313	3.34		
396		"	"	"	6-16	.157	1.44		
397	"	"	"	"	16-	.118			
398	"	"	"	"	0-6	.313	3.40		
399	"	"	"	"	6-16	.171	1.60		
400	"	"	"	"	16-	.129			
401	"	"	"	Cult.	0-6	.183	1.76		
402	"	"	"	"	6-16	.123	1.14		
403	"	"	"	"	0-6	.175	1.67		
404	"	"	"	"	6-16	.187	1.86		
405	Regina - East	Dk.Br.	L.	Sod.	0-6	.331	4.29		
406		"	C.L.	"	6-18	.094	1.15		
407	"	"	"	"	18-	.068			
408	"	"	L.	"	0-6	.323	4.34		
409	"	"	C.L.	"	6-18	.082	1.02		
410	"	"	"	"	18-	.062			
411	"	"	L.	Cult.	0-6	.202	2.61		
412	"	"	C.L.	"	6-16	.069	0.77		
413	"	"	L.	"	0-6	.197	2.53		
414	"	"	C.L.	"	6-16	.085	0.94		
415	Swift Current-S	Lt.Br.	L.	Sod	0-6	.398	5.45		
416		"	"	"	6-15	.109	1.33		
417		"	Si.L.	"	15-30	.054	0.70		
418	"	"	"	"	30-	.033			
419	"	"	L.	"	0-6	.390	5.24		
420	"	"	"	"	6-15	.099	1.20		

Table I (Continued)

Sample No.	Location	Zone & class	Virgin or cult.	Depth in inches	N %	C %	P %	Easily soluble P P.P.M.
421	Swift Current-S	Lt.Br. Si.L.	Sod	15-32	.065	0.82		
422		" "	"	32-	.033			
423		" L.	Cult.	0-6	.271	3.35		
424	"	" "	"	6-15	.118	1.35		
425	"	" Si.L.	"	16-24	.065	0.78		
426	"	" L.	"	0-6	.256	3.23		
427	"	" "	"	6-15	.109	1.22		
428	"	" Si.L.	"	15-24	.084	0.88		
429	Cabri	Lt.Br. C.	Sod	0-7	.136	1.27		
430	"	" "	"	7-21	.097	0.95		
431	"	" "	"	21-	.070			
432	"	" "	"	0-7	.132	1.27		
433	"	" "	"	7-21	.103	0.92		
434	"	" "	"	21-	.087			
435	"	" "	Cult.	0-7	.126	0.87		
436	"	" "	"	7-22	.097	0.89		
437	"	" "	"	0-7	.124	1.16		
438	"	" "	"	7-22	.100	0.89		
439	Lethbridge	Dk.Br. Si.L.	Sod	0-6	.207	2.60		
440		" "	"	6-18	.106	1.20		
441	"	" "	"	18-	.115			
442	"	" "	"	0-6	.205	2.52		
443	"	" "	"	6-18	.097	1.16		
444	"	" "	"	18-	.112			
445	"	" L.	(Cult.	0-6	.133	1.60		
446	"	" Si.L.	(Rot.C	6-12	.100	1.07		
447	"	" "	"	12-	.085			
448	"	" L.	"	0-6	.126	1.52		
449	"	" Si.L.	"	6-12	.117	1.30		
450	"	" "	"	12-	.096			
451	Lacombe	Bl. L.	(Cult.	0-6	.444	5.79		
452	"	" "	(Rot.O	6-15	.257	3.45		
453	"	" Lt.C.L.	"	15-34	.129	1.71		
454	"	" L.	"	0-6	.435	5.72		
455	"	" "	"	6-15	.287	3.81		
456	"	" Lt.C.L.	"	15-34	.048	0.67		
457	Morrin	Dk.Br. C.	Sod	0-6	.417	5.02		
458	"	" "	"	6-12	.216	2.25		
459	"	" "	"	12-20	.154			
460	"	" "	"	0-6	.408	4.78		

Table I (Continued)

Sample No.	Location	Zone & class		Virgin or cult.	Depth in inches	N %	C %	P %	Easily soluble P P.P.M.
461	Morrin	Dk.Br.	C.	Sod	6-12	.210	2.09		
462	"	"	"	"	12-20	.175			
463	"	"	"	Cult.	0-6	.325	3.46		
464	"	"	"	"	6-12	.228	2.22		
465	"	"	"	"	12-20	.214			
466	"	"	"	"	0-6	.325	3.41		
467	"	"	"	"	6-12	.210	1.93		
468	"	"	"	"	12-20	.174			

Total nitrogen was determined on every sample collected.

An analysis of organic carbon was not made on all samples. Lime layer horizons were not analyzed except in a few selected cases because two cultivated and two virgin samples of this horizon were not always obtained at each location. The composite 0 to 7 inch depth (A_0, A_1, and part of A_2 horizon) of virgin gray soils was analyzed, but not the individual surface horizons, since no corresponding horizons were available from the cultivated soil.

Total phosphorus and easily soluble phosphorus were determined on only the surface and subsurface samples collected in 1936. Again these analyses include the composite but not the individual surface samples of the virgin gray soils.

In Table I also may be found the number of each sample, its soil class, approximate location, and the soil zone in which it occurred. Virgin and cultivated soils are designated as such. Two samples collected near one town are differentiated by a letter in brackets after the name of the town. This letter indicates the direction in which the sample was obtained, (S) south, (E) east. Where available, the number of years of cultivation is given. The exact year of breaking was not known in all cases, but any approximations are probably quite close to the actual.

Throughout the areas sampled cropping systems and

farming practices have been very similar. Wheat, oats and barley have been the major crops grown, with a fallow every third or fourth year. No fertilizer treatment had been applied except on one field at MacKay, where a nearby unfertilized field was sampled for comparison.

Different cropping systems have been used in plots sampled at the various experimental stations.

At Brooks, the field sampled had been in alfalfa, under irrigation, for at least ten years before being cropped to grain in 1936.

Two sets of samples were obtained at the Lethbridge Experimental Station, one from Rotation U, under irrigation, and one from Rotation C, dry land. Rotation U consists of a ten year rotation of six years of alfalfa, one beets, one wheat, one oats and one barley. Rotation C is a three year rotation of fallow, wheat and wheat.

At Lacombe two sets of cultivated samples from Rotations C and O, and one set of virgin samples, were obtained. Rotation C is a three year rotation of fallow, wheat and wheat, since 1911. Rotation O is a seven year rotation of potatoes, wheat, oats, fallow, wheat seeded down with alfalfa and western rye, then 2 years of hay.

Two cultivated plots and virgin sod were sampled at the Soils Department experimental field at Breton, Alberta. Plot C 1 has been cultivated at least sixteen years. It has

grown grain except for two years of clover and is unfertilized. Plot C 3 has been cultivated for the same length of time, and cropped similarly, but has been treated with complete fertilizer (N.P.K.S.) for the last seven years.

Edmonton samples were obtained on the University Field Crops farm. Plot A has received a varied treatment; no definite rotation. Wheat, oats and barley have been the principle crops grown, but several years of clovers, hay, and fallow have been interspersed with the grain crops.

Rotation D at Scott has been carried on for only twelve years, and consists of fallow, wheat, oats, and sweet clover.

The data contained in Table I are rearranged and results for nitrogen, carbon and total and easily soluble phosphorus computed on other bases elsewhere in this paper (Tables II to XI inclusive).

Soil Variability, Sampling and Analytical Errors

Soil variability is an important factor to be considered in any discussion of gains or losses of plant foods in cultivated soils. It was found in this work that duplicate soil profiles are not always by any means uniform. Some horizons were found to vary considerably in depth. The A_1 horizon of black soils, for instance, may be 10 or 12

inches deep in one place and 14 or 15 inches deep only a few feet away. If, for example, the A_1 horizon of the sod is shallower than in the cultivated field, the error involved in comparing them can be seen readily.

Within the horizon itself considerable variation may exist in the content of plant food elements, and if single samples only are taken, larger differences may be found between duplicate sod samples than between sod and cultivated samples. This variation can largely be controlled by composite sampling, that is, by taking many borings and lumping them together as one sample for analysis. The closer together the sod and cultivated samples can be taken the smaller will tend to be the variability between the two.

Great care should be taken in the actual sampling itself. It is possible to make a better sampling of surface than subsurface soils. There is always the possibility of inadvertently including some surface soil in samples from lower depths, and it is much easier to take a large number of surface samples, from which to prepare a good composite.

Most analytical methods employed in this work are quite accurate, and while there no doubt is a small personal error involved, it is apt to be much less than the possible one due to soil variability and sampling. In this connection Allison (1) makes the following statements:

"It is recognized that, because of the non-uniform

nature of soils even within short distances, sampling errors usually exceed analytical errors. In order to reduce the sampling error equal to, or below, the error of analysis, a larger number of individual borings is necessary than is ordinarily taken. With 20 borings per twentieth-acre plot, a difference of from 3 to 5 per cent. between duplicate samples frequently occurs, which is reduced only very slightly by further increase in the number of borings per plot. There is little justification, therefore, for attaining, at the expense of much time, a degree of accuracy in analysis far in excess of that which is attained in sampling."

A necessary assumption made in this investigation is that cultivated soils when broken were similar in fertility to nearby virgin sod, which in turn has not changed in fertility. If the cultivated soil was originally more or less fertile than the virgin sod then gains or losses would be less or greater than found at present.

Total Nitrogen Results

In Tables II to XI inclusive may be found a comparison of the nitrogen content of several corresponding horizons of the virgin and cultivated samples from each locality. The samples and results are arranged according to the soil zones in which they occur and each zone is dealt with separately.

Black Soils.

Table II presents the nitrogen analysis of the samples obtained in the black soil zone. The results are expressed on a percentage basis. Because of variability in the soil profile the gain or loss in per cent. nitrogen cannot always be used to indicate the true picture of what has happened to the nitrogen content of the soil at any individual location, as a result of cultivation and cropping. Corresponding horizons were often taken to different depths, so the gain or loss in nitrogen expressed as the difference in per cent. between the virgin and cultivated soils can indicate only what has occurred with respect to the corresponding horizons. Possibly a better idea of actual gains or losses of nitrogen from soil may be had by a comparison of corresponding depths of virgin and cultivated soils. Such a comparison will be made at later points in the discussion of tables dealing with soils from the various zones.

An inspection of Table II shows that there has been a loss of nitrogen from the surface horizon of the cultivated soil in every case. This loss varied from .007 to .179 per cent., but has been more than made up at lower depths in some instances. Five out of nine localities show a gain of from .002 to .177 per cent. in the second horizon, four out of nine a loss of from .012 to .265 per cent. A gain varying from .001 to .053 per cent. is shown in six out of nine cases in the third depth, and a loss of from .007 to .026 per cent. in the other three cases.

Table II. Total nitrogen and loss or gain of nitrogen as per cent. in virgin and cultivated black soils

					Total N		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Per cent.	Av. of duplicate samples	Gain or loss
Edmonton	L.	Virgin	307	0-7	.814		
"	"	"	312	"	.814	.814	
"	"	Plot A 1	317	"	.697		
"	"	Cult. 20 yrs.	321	"	.701	.699	-.115
"	Si.L.	Virgin	309	7-18	.416		
"	"	"	314	"	.320	.368	
"	"	Cult.	319	7-17	.545		
"	"	"	323	"	.544	.545	+.177
"	C.	Virgin	310	18-46	.124		
"	"	"	315	"	.081	.103	
"	"	Cult.	320	17-42	.108		
"	"	"	324	"	.121	.115	+.012
Melfort	L.	Virgin	381	0-7	.648		
"	"	"	385	"	.643	.646	
"	"	Cult. 30 yrs.	389	"	.541		
"	"	" "	392	"	.548	.545	-.101
"	Si.L.	Virgin	382	7-14	.347		
"	"	"	386	"	.293	.320	
"	"	Cult.	390	"	.361		
"	"	"	393	"	.485	.423	+.103
"	C.L.	Virgin	383	14-24	.108		
"	"	"	387	"	.096	.102	
"	"	Cult.	391	"	.168		
"	"	"	394	"	.142	.155	+.053
Lacombe	L.	Virgin	153	0-6	.561		
"	"	"	158	"	.571	.566	
"	"	Cult. 25 yrs.	163	"	.495		
"	"	Rot. C	167	"	.521	.508	-.058
"	"	Virgin	155	6-15	.534		
"	"	"	160	"	.539	.537	
"	"	Cult.	165	"	.408		
"	"	"	169	"	.407	.408	-.129
"	C.L.	Virgin	(156 & (157	15-66	.034		
"	"	"	161	"	.041	.038	
"	"	Cult.	166	"	.039		
"	"	"	170	"	.039	.039	+.001

Table II (Continued)

Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Total N Per cent.	Av. of duplicate samples	Gain or loss
Lacombe	L.	Virgin	153	0-6	.561		
"	"	"	158	"	.571	.566	
"	"	Cult. 26 yrs.	451	"	.444		
"	"	Rot. 0	454	"	.435	.440	-.126
"	"	Virgin	155	6-15	.534		
"	"	"	160	"	.539	.537	
"	"	Cult.	452	"	.257		
"	"	"	455	"	.287	.272	-.265
"	C.L.	Virgin	(156& (157	15-66	.034		
"	"	"	161	"	.041	.038	
"	"	Cult.	453	15-34	.129		
"	"	"	455	"	.048	.089	+.051
Pincher	Si.L.	Virgin	121	0-7	.574		
Creek	"	"	125	"	.580	.577	
"	"	Cult. 27 yrs.	129	"	.399		
"	"	" "	133	"	.396	.398	-.179
"	C.	Virgin	123	7-22	.153		
"	"	"	127	"	.119	.136	
"	"	Cult.	131	"	.126		
"	"	"	135	"	.150	.138	+.002
"	"	Virgin	124	22-28	.069		
"	"	"	128	"	.066	.068	
"	"	Cult.	132	"	.075		
"	"	"	136	"	.080	.078	+.010
Namao	L.	Virgin	256	0-9	.519		
"	"	"	261	"	.499	.509	
"	"	Cult. 30 yrs.	266	"	.397		
"	"	" "	271	0-8	.375	.386	-.123
"	C.	Virgin	258	9-15	.083		
"	"	"	263	"	.123	.103	
"	"	Cult.	268	9-12	.093		
"	"	"	273	8-12	.088	.091	-.012
"	"	Virgin	259	15-36	.073		
"	"	"	264	"	.089	.081	
"	"	Cult.	269	12-58	.062		
"	"	"	274	12-30	.085	.074	-.007
"	Si.L.	Virgin	260	36-46	.046		
"	"	"	265	"	.061	.054	
"	"	Cult.	270	58-82	.061		
"	"	"	275	30-40	.054	.058	+.004

Table II (Continued)

					Total N		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Per cent.	Av. of duplicate samples	Gain or loss
Parkland	L.	Virgin	137	0-6	.438		
"	"	"	141	"	.411	.425	
"	"	Cult. 27 yrs.	145	"	.267		
"	"	" "	149	"	.255	.261	-.164
"	C.L.	Virgin	139	6-20	.140		
"	"	"	143	6-16	.252	.196	
"	"	Cult.	147	6-14	.158		
"	"	"	151	6-13	.161	.160	-.036
"	C.	Virgin	140	20-26	.077		
"	"	"	144	16-22	.143	.110	
"	"	Cult.	148	14-18	.095		
"	"	"	152	13-18	.090	.093	-.017
Lloydminster	L.	Virgin	338	0-5	.411		
	"	"	342	"	.414	.413	
"	"	Cult. 30 yrs.	345	0-7	.396		
"	"	" "	348	"	.402	.399	-.014
"	Si.L.	Virgin	339	5-11	.059		
"	"	"	343	"	.090	.075	
"	"	Cult.	346	7-11	.114		
"	"	"	349	"	.160	.137	+.062
"	C.L.	Virgin	340	11-33	.042		
"	"	"	344	"	.042	.042	
"	"	Cult.	347	11-30	.082		
"	"	"	350	"	.060	.071	+.029
Vegreville	L.	Virgin	276	0-8	.404		
	"	"	280	"	.419	.412	
"	"	Cult. 30 yrs.	284	0-6	.414		
"	"	" "	288	"	.396	.405	-.007
"	C.L.	Virgin	278	8-26	.089		
"	"	"	282	8-34	.060	.075	
"	"	Cult.	286	6-26	.075		
"	"	"	290	6-27	.088	.082	+.007
"	C.	Virgin	279	26-32	.073		
"	"	"	283	34-40	.061	.067	
"	"	Cult.	287	26-32	.036		
"	"	"	291	27-33	.046	.041	-.026

An example of soil variation is shown in samples 309 and 314 at Edmonton (both virgin samples). The per cent. nitrogen found in the 7 to 18 inch depth of duplicate samples was .416 and .320 per cent., a difference of almost .1 per cent. This is an extreme case, but is illustrative of the wide variation that may occur. Another example of how the results from a single sample influence the gain or loss from a horizon is found at Lacombe in the comparison of virgin samples (156 and 157) and 161, and cultivated samples 453 and 455. Virgin samples (156 and 157) and 161 have nitrogen contents of .034 and .041 per cent., cultivated samples 450 and 455 have nitrogen contents of .129 and .048 per cent. respectively. The high figure for the nitrogen content of sample 453 has accentuated the gain shown in this horizon by the cultivated soil.

As previously mentioned, a better idea of the actual nitrogen loss from cultivated black soils, may be had by an examination of Table III, which contains the losses and gains expressed as pounds per acre for the various 6 inch depths. This loss or gain is based on the necessary assumption that cultivated soils were originally similar in fertility to the nearby virgin sod. In making these calculations of the quantities of nitrogen in a given depth it is assumed that each horizon is uniform in composition from top to bottom. At eight out of nine locations (column 1, Table III) losses

of nitrogen varying from 1,582 to 3,222 pounds per acre 6 inches, have occurred. Only at one place, Lloydminster, does the cultivated soil contain more nitrogen than nearby virgin sod. The average loss from all nine cultivated black soil samples to a depth of 6 inches is 1,775 pounds of nitrogen per acre, or 18 per cent. of the original nitrogen content. If Lloydminster were excluded from the average, the loss for 8 locations would be 2,182 pounds per acre or 21 per cent. of the original nitrogen content.

In the second 6 inches there has been a loss of from 443 to 4,770 pounds of nitrogen per acre at six out of nine locations, and a gain of from 1,079 to 2,310 pounds at three locations.

The average loss from all samples in the 6 to 12 inch depth is 602 pounds of nitrogen per acre, or about 11 per cent. of the original. The average loss from the top foot of the cultivated soil is thus about 15 per cent., or 1/6 of the original nitrogen content.

Five out of nine cultivated fields have apparently gained nitrogen in the 12 to 18 inch depth. The average gain for all nine is 25 pounds. The 18 to 24 inch depth in seven out of eight fields have gained in nitrogen content. Though the average gain for eight locations is 299 pounds per acre, this figure is influenced largely by only three places, Melfort, Lacombe (Rot. 0) and Lloydminster, at which the gains were 954, 918 and 522 pounds of nitrogen per acre,

respectively. The single loss was 254 pounds, while the other four gains were 25, 18, 84 and 126 pounds per acre, but these gains are of doubtful significance. A preponderance of increases in cultivated is shown in lower depths, the average for the 24 to 30 inch depth being 168 pounds; this figure again is influenced largely by two locations, Lacombe (Rot. 0) and Lloydminster.

The column at the extreme right of Table III gives the total gain or loss for any single location down to the depth indicated. These figures show that six out of nine cultivated fields have lost nitrogen in amounts ranging from about 1 ton to 3½ tons. Three cultivated fields contain more nitrogen than the sod.

The increases in nitrogen found in lower depths at Edmonton and Melfort are rather difficult to account for. The soil treatment has not been such that a build up in nitrogen would be expected. Organic matter and nitrogen may have been leached down to a certain extent, increasing the nitrogen content at lower depths. Soil variation, especially in the lower depths where composite samples were not obtained, probably has an important bearing on these results. An assumption made in this investigation is that the cultivated soil when broken was very similar in composition to that of nearby virgin sod. In most cases this assumption may hold, but it is not unreasonable to expect that in certain cases it may not.

Table III. Loss or gain of nitrogen in cultivated black soils on a pounds per acre basis

Location	Depth in Inches								Total loss or gain
	0-6	6-12	12-18	18-24	24-30	30-36	36-42	42-66	
Edmonton	-2,070	+2,310	+2,659	+25	+25	+25	+25		+2,999
Melfort	-1,818	+1,242	+1,254	+954					+1,632
Lacombe - Rot. C	-1,044	-2,322	-1,152	+18	+18	+18	+18	+72	-4,374
" - " O	-2,268	-4,770	-1,926	+918	+918				-7,128
Pincher Creek	-3,222	-507	+36	+84					-3,609
Namao	-2,502	-1,359	-254	-254	-254	-254	+108		-4,769
Parkland	-2,952	-648	-1,041						-4,641
Lloydminster	+1,486	+1,079	+522	+522	+522				+4,131
Vegreville	-1,582	-443	+126	+126	-222				-1,995
Average gain or loss	-1,775	-602	+25	+299	+168				

The cultivated samples from Lloydminster (see Table III) show no loss of nitrogen at any depth. Lloydminster is in the parkland belt, characterized by clumps of trees, interspersed with open grassy areas. The virgin profile sampled at this location was obtained from amongst trees and it was observed that beneath the surface five inches of black soil there was a light, gray leached layer, a suggestion of podsolization. In the cultivated field no such distinct evidence of leaching could be found. This cultivated field originally may not have been wooded, but meadow land, and thus not subject to the moister conditions found under tree growth. There is always this possibility of variation when sampling parkland areas.

Dark Brown Soils.

Tables IV and V present the nitrogen data for fields sampled in the dark brown belts of Alberta and Saskatchewan.

Consider first Table IV. Seven out of nine surface horizons show a nitrogen loss of from .019 to .134 per cent. The two gains were .001 and .002 per cent. and quite insignificant. The second horizon shows a small loss in three instances and a small gain in six. The third horizon, as well, has more gains than losses, four out of five, but none is of a large order. Losses were thus confined chiefly to the surface horizon.

Table IV. Total nitrogen and loss or gain of nitrogen as per cent. in virgin and cultivated dark brown soils

					Total N		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Per cent.	Av. of duplicate samples	Gain or loss
Morrin	C.	Virgin	457	0-6	.417		
"	"	"	460	"	.408	.413	
"	"	Cult. 26 yrs.	463	"	.325		
"	"	" "	466	"	.325	.325	-.088
"	"	Virgin	458	6-12	.216		
"	"	"	461	"	.210	.213	
"	"	Cult.	464	"	.228		
"	"	"	467	"	.210	.219	+.006
"	"	Virgin	459	12-20	.154		
"	"	"	462	"	.175	.165	
"	"	Cult.	465	"	.214		
"	"	"	468	"	.174	.194	+.029
Edgerton	L.	Virgin	292	0-8	.342		
"	"	"	296	"	.329	.336	
"	"	Cult. 26 yrs.	300	"	.290		
"	"	" "	303	"	.322	.306	-.030
"	Si.L.	Virgin	294	8-17	.118		
"	"	"	298	8-21	.110	.114	
"	"	Cult.	301	8-20	.110		
"	"	"	305	"	.126	.118	+.004
"	"	Virgin	295	17-24	.058		
"	"	"	299	21-27	.065	.062	
"	"	Cult.	302	20-26	.069		
"	"	"	306	"	.067	.068	+.006
Cutknife	L.	Virgin	361	0-7	.337		
"	"	"	364	"	.335	.336	
"	"	Cult. 31 yrs.	367	"	.242		
"	"	" "	369	"	.241	.242	-.094
"	Si.L.	Virgin	362	7-22	.087		
"	"	"	365	7-28	.068	.078	
"	"	Cult.	368	7-26	.063		
"	"	"	370	7-22	.063	.063	-.015
Regina - East	L.	Virgin	405	0-6	.331		
"	"	"	408	"	.323	.327	
"	"	Cult. 49 yrs.	411	"	.202		
"	"	" "	413	"	.197	.200	-.127
"	C.L.	Virgin	406	6-18	.094		
"	"	"	409	"	.082	.088	
"	"	Cult.	412	6-16	.069		
"	"	"	414	"	.085	.077	-.011

Table IV (Continued)

					Total N		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Per cent.	Av. of duplicate samples	Gain or loss
Regina -	C.	Virgin	395	0-6	.313		
South	"	"	398	"	.313	.313	
"	"	Cult. 50 yrs.	401	"	.183		
"	"	" "	403	"	.175	.179	-.134
"	"	Virgin	396	6-16	.157		
"	"	"	399	"	.171	.164	
"	"	Cult.	402	"	.123		
"	"	"	404	"	.187	.155	-.009
Scott	L.	Virgin	351	0-7	.240		
"	"	"	354	"	.257	.249	
"	"	(Cult. 12 yrs.	357	"	.247		
"	"	(Rot. D	359	"	.253	.250	+.001
"	Si.L.	Virgin	352	7-14	.085		
"	"	"	355	"	.091	.088	
"	"	Cult.	358	"	.094		
"	"	"	360	"	.085	.090	+.002
Hand	L.	Virgin	17	0-8	.207		
Hills	"	"	20	"	.234	.221	
"	"	Cult. 20 yrs.	23	0-6	.239		
"	"	" "	26	0-8	.207	.223	+.002
"	C.L.	Virgin	18	8-14	.102		
"	"	"	21	"	.110	.106	
"	"	Cult.	24	6-12	.149		
"	"	"	27	8-14	.119	.134	+.028
"	C.	Virgin	19	14-22	.057		
"	"	"	22	"	.065	.061	
"	"	Cult.	25	12-20	.070		
"	"	"	28	14-22	.078	.074	+.013
Leth-	Si.L.	Virgin	105	0-5	.210		
bridge	"	"	109	"	.217	.214	
"	"	(Cult.	113	"	.198		
"	"	(Rot. U	117	"	.192	.195	-.019
"	"	Virgin	107	5-12	.158		
"	"	"	111	"	.147	.153	
"	"	Cult.	115	5-10	.173		
"	"	"	119	"	.168	.171	+.018

Table IV (Continued)

					Total N		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Per cent.	Av. of duplicate samples	Gain or loss
Lethbridge	Si.L.	Virgin	108	12-18	.096		
	"	"	112	"	.077	.087	
"	"	Cult.	116	10-16	.113		
"	"	"	120	"	.126	.120	+.033
Lethbridge	Si.L.	Virgin	439	0-6	.207		
	"	"	442	"	.205	.206	
"	"	(Cult. Rot. C	445	"	.133		
"	"	(Dry land	448	"	.126	.130	-.076
"	"	Virgin	440	6-18	.106		
"	"	"	443	"	.097	.102	
"	"	Cult.	446	6-12	.100		
"	"	"	449	"	.117	.109	+.007
"	"	Virgin	441	18-	.115		
"	"	"	444	"	.112	.114	
"	"	Cult.	447	12-	.085		
"	"	"	450	"	.096	.091	-.023

Gains or losses of nitrogen on a pounds per acre basis are shown in Table V. The surface 6 inches of eight out of nine cultivated fields have lost nitrogen in amounts ranging from 168 to 2,286 pounds. The one increase was at Scott. Cultivation had been carried on in this field for only twelve years, and the gain was only 18 pounds which is quite insignificant. The average loss from the surface 6 inches of all dark brown cultivated fields was 1,145 pounds, or about 22 per cent. of the original.

Table V. Loss or gain of nitrogen in cultivated dark brown soils on a pounds per acre basis

Location	Depth in Inches 0-6	6-12	12-18	18-24	Total loss or gain
Morrin	-1,584	+108	+522		-954
Edgerton	-540	-42	+207	+101	-274
Cutknife	-1,692	-492	-204	-204	-2,592
Regina (E)	-2,286	-198	-198		-2,682
" (S)	-2,412	-162	-162		-2,736
Scott	+ 18	+36			+54
Hand Hills	-168	+122	+245	+245	+444
Lethbridge - Rot. U	-275	+60	+594		+379
" - " C	-1,368	+126	-198		-1,440
Av. loss or gain	-1,145	-47	+101		

In the 6 to 12 inch depth there was a small decrease at four locations, and a small increase at five. The average loss from the 6 to 12 inch depth was only 47 pounds.

The 12 to 18 inch depth of the eight samples collected breaks even in gains and losses, four and four, and the average gain for all samples of cultivated is 101 pounds.

The total gain or loss of nitrogen in each cultivated profile is shown in the column at the right of Table V. Six out of nine locations have been decreased in nitrogen content, this decrease varying from 274 to 2,736 pounds of nitrogen per acre. Gains of 54, 444 and 381 pounds of nitrogen are recorded at three locations.

Brown Soils.

Data for the nitrogen content of the brown soils are contained in Tables VI and VII.

Differences in per cent. nitrogen in favor of the surface horizon of virgin soils occurred at six out of eight locations. The sod was higher in amounts varying from .009 to .130 per cent. Two cultivated soils were higher than the virgin soil by .003 and .005 per cent. but these differences are quite insignificant. A loss is shown in the subsurface cultivated at four locations, a gain at three and neither a gain nor loss in another. Four fields out of six show a loss in the third horizon, two a gain, but none of the losses or gains are very large. The figures indicate that general losses are confined chiefly to the surface.

Table VI. Total nitrogen and loss or gain of nitrogen as per cent. in virgin and cultivated brown soils

Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Total N Per cent.	Total N Av. of duplicate samples	Total N Gain or loss
Swift Current (S)	L.	Virgin	415	0-6	.398		
	"	"	419	"	.390	.394	
	"	Cult. 30 yrs.	423	"	.271		
"	"	" "	426	"	.256	.264	-.130
"	"	Virgin	416	6-15	.109		
"	"	"	420	"	.099	.104	
"	"	Cult.	424	6-16	.118		
"	"	"	427	6-15	.109	.114	+.010
"	Si.L.	Virgin	417	15-30	.054		
"	"	"	421	15-32	.065	.060	
"	"	Cult.	425	16-24	.065		
"	"	"	428	15-24	.084	.075	+.015
Gros Ventre	L.	Virgin	73	0-6	.295		
	"	"	77	"	.287	.291	
"	"	Cult. 20 yrs.	81	"	.186		
"	"	" "	85	"	.185	.186	-.105
"	C.L.	Virgin	75	6-20	.105		
"	"	"	79	"	.116	.111	
"	"	Cult.	83	6-20	.075		
"	"	"	87	6-24	.081	.078	-.033
"	C.	Virgin	76	20-26	.092		
"	"	"	80	"	.075	.084	
"	"	Cult.	84	"	.050		
"	"	"	88	24-30	.054	.052	-.032
Swift Current	L.	Virgin	57	0-6	.254		
	"	"	61	"	.278	.266	
"	"	Cult. 20 yrs.	65	"	.264		
"	"	" "	69	"	.278	.271	+.005
"	"	Virgin	59	6-18	.117		
"	"	"	63	"	.111	.114	
"	"	Cult.	67	"	.082		
"	"	"	71	"	.104	.093	-.021
"	C.	Virgin	60	18-24	.080		
"	"	"	64	"	.104	.092	
"	"	Cult.	68	"	.062		
"	"	"	72	"	.083	.073	-.019

Table VI (Continued)

					Total N		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Per cent.	Av. of duplicate samples	Gain or loss
Acadia Valley	C.	Virgin	29	0-6	.156		
	"	"	32	"	.147	.152	
"	"	Cult. 22 yrs.	35	"	.153		
"	"	" "	38	"	.156	.155	+.003
"	"	Virgin	31	6-8	.099		
"	"	"	34	"	.107	.103	
"	"	Cult.	37	"	.101		
"	"	"	40	"	.096	.099	-.004
Cavendish	F.S.L.	Virgin	41	0-5	.158		
"	"	"	45	"	.146	.152	
"	"	Cult. 23 yrs.	49	"	.130		
"	"	" "	53	"	.110	.120	-.032
"	"	Virgin	43	5-12	.093		
"	"	"	47	"	.105	.099	
"	"	Cult.	51	"	.122		
"	"	"	55	"	.102	.112	+.013
"	L.	Virgin	44	12-20	.059		
"	"	"	48	"	.087	.073	
"	"	Cult.	52	12-18	.065		
"	"	"	56	"	.069	.067	-.006
Brooks	F.S.L.	Virgin	1	0-9	.158		
"	"	"	5	"	.159	.159	
"	"	(Cult.	9	"	.105		
"	"	(Irrig.	13	"	.097	.101	-.058
"	"	Virgin	2	9-16	.062		
"	"	"	6	"	.063	.063	
"	"	Cult.	10	"	.080		
"	"	"	14	"	.069	.075	+.012
"	"	Virgin	3	16-36	.045		
"	"	"	7	"	.033	.039	
"	"	Cult.	11	"	.047		
"	"	"	15	"	.047	.047	+.008
"	"	Virgin	4	36-42	.024		
"	"	"	8	"	.039	.032	
"	"	Cult.	12	"	.042		
"	"	"	16	"	.031	.037	+.005

Table VI (Continued)

					Total N		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Per cent.	Av. of duplicate samples	Gain or loss
Cabri	C.	Virgin	429	0-7	.136		
"	"	"	432	"	.132	.134	
"	"	Cult. 26 yrs.	435	"	.126		
"	"	" "	437	"	.124	.125	-.009
"	"	Virgin	430	7-21	.097		
"	"	"	433	"	.103	.100	
"	"	Cult.	436	7-22	.097		
"	"	"	438	"	.100	.099	-.001
Many-berries	L.	Virgin	89	0-6	.111		
"	"	"	93	"	.123	.117	
"	"	Cult. 23 yrs.	97	"	.101		
"	"	" "	101	"	.090	.096	-.021
"	Si.L.	Virgin	91	6-14	.090		
"	"	"	95	"	.079	.085	
"	"	Cult.	99	"	.084		
"	"	"	103	"	.086	.085	
"	"	Virgin	92	14-20	.054		
"	"	"	96	"	.077	.066	
"	"	Cult.	100	14-18	.084		
"	"	"	104	"	.044	.064	-.002

On a pounds per acre basis (Table VII) the surface 6 inch layer of six out of the eight cultivated fields has been decreased in nitrogen by amounts ranging from 160 to 2,340 pounds per acre. Acadia Valley and Swift Current show increases of 54 and 90 pounds. The Swift Current sample deviates from the usual in that a gain of 90 pounds of nitrogen is shown in the surface 6 inches of the cultivated, but a loss of 1,098 pounds is shown in the next 18 inches. The average loss from all brown samples down to a depth of 6 inches is 765 pounds per acre, or slightly more than 20 per cent. of the original nitrogen content as measured by the virgin sod.

Table VII. Loss or gain of nitrogen in cultivated brown soils on a pounds per acre basis

Location	Depth in Inches					Total loss or gain
	0-6	6-12	12-18	18-24	24-42	
Swift Current (S)	-2,340	+171	+242	+314		-1,613
Gros Ventre	-1,890	-594	-594	-474		-3,552
Acadia Valley	+54					+54
Swift Current	+90	-378	-378	-342		-1,008
Cavendish	-441	+234	-108			-315
Brooks	-1,044	-414	+192	+144	+378	-744
Cabri	-162	-42	-18			-222
Manyberries	-387	+9	-21			-399
Av. loss or gain	-765	-145	-98			

In the 6 to 12 inch depth four out of seven cultivated fields are lower in nitrogen content, and the average loss is 145 pounds per acre. This represents 8 per cent. of the original nitrogen content. Therefore the total loss from the first foot of the brown soils is 924 pounds per acre or 14 per cent. of the original.

In the 12 to 18 inch depth nitrogen decreases occurred in five out of seven cultivated cases, the average loss being 98 pounds. This also represents about 8 per cent. of the original nitrogen content. The total average loss in the brown soils to a depth of 18 inches is 1,008 pounds per acre, or they contain about 12 per cent. less nitrogen than the corresponding sod. Total gains or losses of nitrogen for each sample is shown in the column at the extreme right of Table VII. Losses of from 222 to 3,552 pounds per acre occurred in seven out of eight samples. The single gain, at Acadia Valley, was 54 pounds per acre.

Gray Transition Soils.

Data as to gains or losses of nitrogen in gray transition soils are very meager, only two samples from this zone having been collected. The per cent. nitrogen figures in Table VIII show an increase in cultivated surface soil at Colinton and a loss at Grosmont. In both places the subsurface horizons of cultivated have lost nitrogen in small amounts, while the greatest loss is found in the third depth at Colinton, .015 per cent.

Table VIII. Total nitrogen and loss or gain of nitrogen as per cent. in virgin and cultivated gray transition soils

					Total N		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Per cent.	Av. of duplicate samples	Gain or loss
Colinton	Si.L.	Virgin	238	0-8	.105		
"	"	"	243	"	.140	.123	
"	"	Cult. 20 yrs.	246	0-6	.155		
"	"	" "	251	"	.156	.156	+.033
"	"	Virgin	239	8-13	.027		
"	"	"	244	"	.039	.033	
"	"	Cult.	248	6-9	.039		
"	"	"	249	9-13	.013		
"	"	"	253	6-9	.017		
"	"	"	254	9-13	.013	.020	-.013
"	C.	Virgin	240	13-25	.035		
"	"	"	245	"	.035	.035	
"	"	Cult.	250	"	.019		
"	"	"	255	"	.020	.020	-.015
Grosmont	Si.L.	Virgin	327	0-8	.135		
"	"	"	332	"	.139	.137	
"	"	Cult. 27 yrs.	334	"	.134		
"	"	" "	336	"	.135	.135	-.002
"	C.L.	Virgin	328	8-20	.064		
"	"	"	333	"	.060	.062	
"	"	Cult.	335	"	.066		
"	"	"	337	"	.054	.060	-.002

Data in Table IX indicate a loss of nitrogen in cultivated at both locations in every depth except the surface 6 inches at Colinton. Total losses were 726 pounds at Colinton and 96 pounds at Grosmont. From the standpoint of application to gray transition soils generally, the data from analysis of only two samples are not conclusive.

Table IX. Loss or gain of nitrogen in cultivated gray transition soils on a pounds per acre basis

	Depth in Inches				Total loss or gain
Location	0-6	6-12	12-18	18-24	
Colinton	+18	-198	-276	-270	-726
Grosmont	-24	-36	-36		-96
Av. loss or gain	-3	-117	-156		

Gray Soils.

Results from the nitrogen determinations on gray wooded soil samples are reported in Tables X and XI. In Table X it can be seen that five surface horizons out of six show losses of nitrogen varying from .025 to .064 per cent. The gain in the sixth case is .003 per cent., which is insignificant. The analysis of second horizons show small losses of .002, .007 and .008 per cent. and gains of .002 and .007 per cent. Nitrogen decreases of .005 and .003 per cent. are shown in the five to six foot depths at Breton.

Table X. Total nitrogen and loss or gain of nitrogen as per cent. in virgin and cultivated gray soils

					Total N		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Per cent.	Av. of duplicate samples	Gain or loss
Breton	Si.L.	Virgin	173	0-7	.158		
"	"	"	178	"	.137	.148	
"	"	(Ser. Cl Check	181	"	.087		
"	"	(Cult. 16 yrs.	185	"	.081	.084	-.064
"	C.	Virgin	174	7-60	.032		
"	"	"	179	"	.032	.032	
"	"	Cult.	183	7-64	.027		
"	"	"	187	"	.021	.024	-.008
"	"	Virgin	175	60-70	.017		
"	"	"	180	"	.024	.021	
"	"	Cult.	184	64-74	.011		
"	"	"	188	"	.020	.016	-.005
Breton	Si.L.	Virgin	173	0-7	.158		
"	"	"	178	"	.137	.148	
"	"	(Ser.C Complete	189	"	.078		
"	"	(Cult. 16 yrs.	193	"	.096	.087	-.061
"	C.	Virgin	174	7-60	.032		
"	"	"	179	"	.032	.032	
"	"	Cult.	191	7-65	.029		
"	"	"	195	"	.023	.026	-.006
"	"	Virgin	175	60-70	.017		
"	"	"	180	"	.024	.021	
"	"	Cult.	192	65-75	.020		
"	"	"	196	"	.015	.018	-.003
Fallis	Si.L.	Virgin	199	0-7	.123		
"	"	"	204	"	.135	.129	
"	"	Cult. 24 yrs.	206	"	.066		
"	"	" "	210	"	.069	.068	-.061
"	C.	Virgin	200	7-60	.030		
"	"	"	205	"	.030	.030	
"	"	Cult.	208	7-48	.033		
"	"	"	212	"	.030	.032	+.002

Table X (Continued)

Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Total N: Per cent.	Total N: Av. of duplicate samples	Total N: Gain or loss
Tweedsmuir	F.S.L.	Virgin	371	0-7	.115		
"	"	"	374	"	.109	.112	
"	"	Cult. 12 yrs.	377	"	.079		
"	"	" "	379	"	.079	.079	-.033
"	S.L.	Virgin	372	7-36	.012		
"	"	"	375	"	.010	.011	
"	"	Cult.	378	"	.010		
"	"	"	380	"	.007	.009	-.002
MacKay	Si.L.	Virgin	216	0-7	.066		
"	"	"	222	"	.078	.072	
"	"	(Cult. 5 yrs.	226	"	.075		
"	"	(Fertilized	229	"	.075	.075	+.003
"	C.	Virgin	217	7-48	.030		
"	"	"	223	"	.027	.029	
"	"	Cult.	228	"	.033		
"	"	"	231	7-50	.039	.036	+.007
MacKay	Si.L.	Virgin	216	0-7	.066		
"	"	"	222	"	.078	.072	
"	"	(Cult. 3 yrs.	232	"	.041		
"	"	(No Fert.	234	"	.053	.047	-.025

Table XI presents the nitrogen gains or losses in various 6 inch depths of the six gray wooded soils examined. Losses varying from 450 to 1,152 pounds of nitrogen per acre 6 inches occurred in five cultivated soils. One field showed disagreement, increasing by 54 pounds. The average loss from the surface 6 inches of cultivated gray wooded soils is 723 pounds, or 35 per cent. of the original nitrogen content.

Table XI. Loss or gain of nitrogen in cultivated gray soils on a pounds per acre basis

	Depth in Inches						Total loss or gain
Location	0-6	6-12	12-18	18-24	24-30	30-48	
Breton C 1	-1,152	-312	-144	-144	-144	-432	-2,328
" C 3	-1,098	-273	-108	-108	-108	-324	-2,019
Fallis	-1,098	-153	+36	+36	+36	+108	-1,035
Tweedsmuir	-594	-129	-36	-36	-36		-831
MacKay-Fert.	+54	+114	+126	+126	+126	+378	+924
" No fert.	-450						-450
Av. loss or gain	-723	-151	-25	-25	-25	-68	

In the 6 to 12 inch depth four locations out of five have lost nitrogen, the average loss being 151 pounds or 20 per cent. The total average loss from the top foot of cultivated gray wooded soils is 874 pounds of nitrogen per acre or 28 per cent. of the original nitrogen content.

Losses in lower levels are shown in the two cultivated fields at Breton, and gains at Fallis, Tweedsmuir and the fertilized field at MacKay.

Considering the total nitrogen gains or losses for individual locations, it can be seen that losses of from 450 to 2,328 pounds of nitrogen occur in five instances. The single gain is at MacKay, where the cultivated field contained more nitrogen at every level than the nearby virgin sod.

The effect of length of time of cultivation on nitrogen loss

Most of the cultivated soils in the black soil zone have been cultivated between 25 and 30 years. There does not appear to be any very close relation between loss or gain of nitrogen and the number of years of cropping.

The greatest total loss of nitrogen in samples collected in the dark brown zone occurred at Regina where cultivation has been carried on for 50 years. This loss, however, was very little greater than that found at Cutknife cultivated for 31 years. It is three times the loss found at Morrin, cultivated 31 years, and twice the loss in Rotation C at Lethbridge cultivated for about 30 years. The one sample in which no loss of any kind is shown is at Rotation D, Scott, cultivated for only 12 years. Thus the loss of nitrogen has not been proportional to the years of cultivation, though fields cultivated for the greatest length of time show the largest loss.

The brown soil samples collected have been cultivated for about the same length of time. Since losses and gains of nitrogen were found, there has been apparently no very close relation between loss or gain of nitrogen and the number of years of cultivation.

The samples from the gray transition and gray soils show little direct relation between years cultivated and nitrogen loss. The MacKay sample, after cultivation for three years shows a loss of 450 pounds of nitrogen per acre. Fallis, cultivated for 24 years, lost 1,035 pounds and the Breton plots lost over a ton of nitrogen per acre after 16 years of cultivation.

The effect of soil class on loss of nitrogen

All samples as they were collected were classed by moistening and rubbing in the palm of the hand. Corresponding sod and cultivated horizons classed the same and previous tables have shown the gain or loss of nitrogen for each horizon.

The following table is a summation of all surface, subsurface and subsoil classes, and the number of gains or losses in cultivated soil that occur with each.

Table XII. The number of losses and gains that occurred in each cultivated surface, subsurface and subsoil class

Soil class	No. of samples	Surface Gains	Surface Losses	Subsurface & Subsoil Gains	Subsurface & Subsoil Losses
Loam	22	3	17	1	1
Silt Loam	25	2	8	11	4
Fine Sandy Loam	7	-	3	4	--
Sandy Loam	2	-	--	1	1
Clays	26	1	3	8	14
Clay Loams	10	-	--	6	4

One silt loam sample not included shows neither gain nor loss. Surface loams, silt loams, fine sandy loams and clays show losses more often than gains. Thus losses in cultivated have occurred in surface soils regardless of the soil class. Most subsurface and subsoils were classed as silt loams, clays and clay loams. Silt loams and clay loams show more gains in cultivated than losses, and clays more losses than gains. The clays are more numerous than either silt loams or clay loams, and since it is felt that other perhaps more important factors enter into the question of gains and losses, hesitation is felt about making the general statement that subsurface and subsoil clays are conducive to nitrogen losses under cultivation, while silt loams and clay loams are not.

The effect of cropping systems on nitrogen gains or losses

Twenty-seven fields examined in this work, including

Rotations C at Lacombe and Lethbridge, have grown the three common grain crops chiefly with a fallow every three or four years. Twenty-three of these cultivated fields showed a lower total nitrogen content of from 96 to 4,769 pounds per acre than did the corresponding virgin sod. Four cultivated fields showed a gain of from 54 to 4,131 pounds of nitrogen per acre. It would appear that a straight grain and fallow system does not maintain the nitrogen content of the soil, but is conducive to considerable losses since 14 cultivated fields examined have lost 1,000 pounds or more nitrogen per acre.

Out of seven additional plots which were subjected to cropping systems other than straight grain and fallow, six show a loss of nitrogen in the first 6 inches, but two of these gained enough in lower depths to more than make up this loss, so a gain in total nitrogen is shown in three out of seven plots.

The 7 year rotation at Lacombe has apparently not maintained the nitrogen content. As a matter of fact, this Rotation, O, shows a loss of about 2800 pounds more nitrogen than nearby Rotation C, a three year rotation of wheat, wheat and fallow. Only one set of sod samples was taken, near Rotation C. Rotation O is further away, and soil variation has probably had the effect of making this loss appear greater than actually occurred.

Rotation D at Scott has maintained the nitrogen content for twelve years.

An interesting comparison of a grain and fallow dry land system (Rotation C), and a rotation including six years of alfalfa under irrigation (Rotation U) can be made at Lethbridge. Both plots show a surface loss of nitrogen, but the loss from Rotation U has been only 267 pounds, about 1/5 of the loss in Rotation C. Rotation C has lost altogether 1,440 pounds of nitrogen, Rotation U has gained 381 pounds. Irrigation and a rotation including six years of alfalfa have at least maintained the nitrogen content in the top 18 inches of soil.

At Brooks a field irrigated and cropped to alfalfa for at least ten years, shows a total loss of nitrogen of 816 pounds. This is contrary to what occurred at Lethbridge in the plot there treated somewhat similarly.

The Breton plots C 1 and C 3 subjected to a four year rotation of one year of clover and three of grain, present a comparison of fertilized and unfertilized fields. A yearly application of about 15 pounds of nitrogen in a complete fertilizer (N.P.K.S.), over a period of seven years, has increased the total nitrogen content of Plot C 3 by about 300 pounds per acre.

It is difficult to understand how an application of ammonium sulphate fertilizer for one or two years on the fertilized field at MacKay could cause an increase in total

nitrogen content of 924 pounds. It is quite probable in this case that the cultivated field was originally more fertile than the nearby sod, always a possibility in a comparison of this kind. There is also, of course, the possibility that a cultivated field was originally less fertile than the sod is at present and this fact would accentuate apparent losses.

The data reported represents the analysis of only a few plots, and no sweeping conclusions can be drawn as to the relative value of the various systems used. It would appear, however, that since six plots out of seven show a decrease of nitrogen in the surface 6 inches, rotations alone do not maintain or increase the nitrogen content to this depth.

Summary of nitrogen determinations

Twenty-five cultivated fields from widely separated points in Alberta and Saskatchewan have lost nitrogen to the depths sampled, in amounts varying from 96 to 7,128 pounds per acre. Nine cultivated fields have gained nitrogen in amounts varying from 54 to 4,131 pounds per acre.

The average loss from the top 6 inches of all cultivated black soils analyzed is 1,775 pounds per acre, or 18 per cent. of the original nitrogen content. The loss from the second 6 inches is 602 pounds per acre, about 11 per cent. of the original.

The average loss from the top six inches of the cultivated dark brown soil samples is 1,145 pounds, or about 22 per cent. of the original nitrogen content. The average loss of 47 pounds in the next six inches is a very small amount and probably not significant.

The cultivated brown soils have lost 20 per cent. of their nitrogen in the top six inches, or 765 pounds per acre. The loss from 6 to 12 inches is 145 pounds or 8 per cent. of the original nitrogen content. The loss from the 12 to 18 inch depth is 98 pounds or about 8 per cent.

The surface six inches of gray soils have lost 35 per cent. of their nitrogen on the average as a result of cultivation and cropping. The average loss in pounds per acre to this depth is 723 pounds. The 6 to 12 inch depth has lost 151 pounds or 20 per cent.

Probably the most reliable figures obtained are for the surface gains or losses.

Nitrogen losses shown by the cultivated soils are, if anything, on the conservative side. Some of the heavier grass growth and roots, which would normally be turned under by a farmer, were removed from the virgin samples before they were ground for analysis.

It has been clearly demonstrated that a straight grain and fallow system does not maintain the nitrogen content of western Canada prairie soils.

Organic Carbon Results

Though the term carbon will be used throughout this section, it should be noted that it will apply only to organic carbon. An analysis of carbonates was not made.

Black Soils.

Table XIII presents the per cent. carbon and the gains and losses of per cent. carbon in the black soil samples analyzed. It can be seen that every cultivated field has less carbon in the surface horizon than the corresponding sod. The differences in favor of the sod vary from .25 to 2.99 per cent. The subsurface horizons have lost carbon in five instances, the losses varying from .01 to 3.23 per cent. Four gains are shown, representing increases of from .02 to 2.44 per cent. The subsoil horizons show an increase in four cases, the increases varying between .02 to .57 per cent. Losses from two locations are of the order of .17 and .14 per cent. Thus losses occur throughout the surface horizons generally and occasionally in lower horizons.

In Table XIV may be found the losses or gains in pounds per acre that occurred in the cultivated samples. The profiles are divided into 6 inch depths. At eight locations out of nine the surface 6 inches of the cultivated soils have lost carbon in amounts varying from 11,160 pounds per acre at Lacombe to 53,820 pounds at Pincher Creek. The average loss

to a six inch depth for all samples in the black belt is 26,626 pounds of carbon per acre, or 45,903 pounds of organic matter. This loss amounts to 21 per cent. of the original measured by the carbon content of the sod.

Six out of nine cultivated fields show a decrease of carbon in the 6 to 12 inch depth; three fields show a gain. Losses varied from 7,754 to 58,140 pounds, gains from 9,930 to 32,460 pounds. The average loss of carbon for all samples in the 6 to 12 inch depth is 8,808 pounds per acre, which is equivalent to 15,185 pounds of organic matter. This loss represents 21 per cent. of the original content.

The average loss for all cultivated black soil samples to a depth of one foot is about 18 tons of carbon, which means 31 tons of organic matter. Twenty-one per cent. of the original carbon or organic matter has apparently been lost.

In the 12 to 18 inch depth four losses and four gains of carbon are shown. In the 18 to 24 inch depth more gains than losses occurred, five of the former and two of the latter. Lower depths, including the samples in the 24 to 30, 30 to 36, and 36 to 42 inch depths are evenly divided in gains and losses, five and five.

Table XIII. Total organic carbon and loss or gain of organic carbon as per cent. in virgin and cultivated black soils

					Total Organic C		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Per cent.	Av. of duplicate samples	Gain or loss
Edmonton	L.	Virgin	307	0-7	9.84		
"	"	"	312	"	10.05	9.95	
"	"	(Cult. 20 yrs.	317	"	8.66		
"	"	(Plot A 1	321	"	8.47	8.57	-1.38
"	Si.L.	Virgin	309	7-18	4.83		
"	"	"	314	"	3.50	4.17	
"	"	Cult.	319	7-17	6.70		
"	"	"	323	"	6.52	6.61	+2.44
"	C.	Virgin	310	18-46	1.18		
"	"	"	315	"	0.76	.97	
"	"	Cult.	320	17-42	1.34		
"	"	"	324	"	1.20	1.27	+0.30
Melfort	L.	Virgin	381	0-7	8.41		
"	"	"	385	"	8.30	8.36	
"	"	Cult. 30 yrs.	389	"	6.96		
"	"	" "	392	"	7.08	7.02	-1.34
"	Si.L.	Virgin	382	7-14	4.43		
"	"	"	386	"	3.68	4.06	
"	"	Cult.	390	"	4.38		
"	"	"	393	"	5.60	4.99	+0.93
"	C.L.	Virgin	383	14-24	1.31		
"	"	"	387	"	1.19	1.25	
"	"	Cult.	391	"	1.95		
"	"	"	394	"	1.61	1.78	+0.53
Lacombe	L.	Virgin	153	0-6	7.51		
"	"	"	158	"	7.26	7.39	
"	"	(Cult. 25 yrs.	163	"	6.63		
"	"	(Rot. C	167	"	6.91	6.77	-0.62
"	"	Virgin	155	6-15	6.95		
"	"	"	160	"	6.77	6.86	
"	"	Cult.	165	"	5.36		
"	"	"	169	"	5.53	5.45	-1.41
"	C.L.	Virgin	156	15-54	0.61		
"	"	"	161	15-66	0.62	0.62	
"	"	Cult.	166	"	0.42		
"	"	"	170	"	0.47	0.45	-0.17

Table XIII (Continued)

					Total Organic C		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Per cent.	Av. of duplicate samples	Gain or loss
Lacombe	L.	Virgin	153	0-6	7.51		
"	"	"	158	"	7.26	7.39	
"	"	(Cult. 26 yrs.	451	"	5.79		
"	"	(Rot. 0	454	"	5.72	5.76	-1.63
"	"	Virgin	155	6-15	6.95		
"	"	"	160	"	6.77	6.86	
"	"	Cult.	452	"	3.45		
"	"	"	455	"	3.81	3.63	-3.23
"	C.L.	Virgin	156	15-54	0.61		
"	"	"	161	15-66	0.62	0.62	
"	"	Cult.	453	15-34	1.71		
"	"	"	456	"	0.67	1.19	+0.57
Pincher Creek	Si.L.	Virgin	121	0-7	8.01		
	"	"	125	"	7.93	7.97	
"	"	Cult. 27 yrs.	129	"	4.91		
"	"	" "	133	"	5.04	4.98	-2.99
"	C.	Virgin	123	7-22	1.72		
"	"	"	127	"	1.33	1.53	
"	"	Cult.	131	"	1.40		
"	"	"	135	"	1.63	1.52	-0.01
Namao	L.	Virgin	256	0-9	7.76		
"	"	"	261	"	6.58	7.17	
"	"	Cult. 30 yrs.	266	"	5.01		
"	"	" "	271	0-8	5.02	5.02	-2.15
"	C	Virgin	258	9-15	0.85		
"	"	"	263	"	1.30	1.08	
"	"	Cult.	268	9-12	0.93		
"	"	"	273	8-12	0.84	0.89	-0.19
"	"	Virgin	259	15-36	0.74		
"	"	"	264	"	0.87	0.81	
"	"	Cult.	269	12-58	0.66		
"	"	"	(274& (275	12-40	0.67	0.67	-0.14

Table XIII (Continued)

					Total Organic C		
Location	Soil class	Virgin or cultivated	Sample	Depth in inches	Per cent.	Av. of duplicate samples	Gain or loss
Parkland	L.	Virgin	137	0-6	6.03		
"	"	"	141	"	5.68	5.86	
"	"	Cult. 27 yrs.	145	"	3.39		
"	"	" "	149	"	3.27	3.33	-2.53
"	C.L.	Virgin	139	6-20	1.67		
"	"	"	143	6-16	3.09	2.38	
"	"	Cult.	147	6-14	1.78		
"	"	"	151	6-13	1.89	1.84	-0.54
Lloydminster	L.	Virgin	338	0-5	5.33		
	"	"	342	"	5.50	5.42	
"	"	Cult. 30 yrs.	345	0-7	5.03		
"	"	" "	348	"	5.11	5.07	-0.35
"	Si.L.	Virgin	339	5-11	0.70		
"	"	"	343	"	1.11	0.91	
"	"	Cult.	346	7-11	1.31		
"	"	"	349	"	1.88	1.60	+0.69
"	C.L.	Virgin	340	11-33	0.47		
"	"	"	344	"	0.55	0.51	
"	"	Cult.	347	11-30	0.92		
"	"	"	350	11-28	0.77	0.85	+0.34
Vegreville	L.	Virgin	276	0-8	5.39		
	"	"	280	"	5.60	5.50	
"	"	Cult. 30 yrs.	284	0-6	5.31		
"	"	" "	288	"	5.18	5.25	-0.25
"	C.L.	Virgin	278	8-26	1.08		
"	"	"	282	8-34	0.72	0.90	
"	"	Cult.	286	6-26	0.85		
"	"	"	290	6-27	0.99	0.92	+0.02

Table XIV. Loss or gain of organic carbon in cultivated black soils on a pounds per acre basis

Location	Depth in Inches							Total organic carbon	Total organic matter
	0-6	6-12	12-18	18-24	24-30	30-36	36-42		
Edmonton	-24,840	+32,460	+37,116	+3,096	+3,096	+3,096	+6,192	+63,912	+110,184
Melfort	-24,120	+9,930	+11,940	+9,540				+7,290	+12,568
Lacombe - Rot. C	-11,160	-25,380	-14,220	-3,060	-3,060	-3,060	-3,060	-63,000	-108,612
" - " 0	-29,340	-58,140	-23,940	+10,260	+10,260			-90,900	- 156,712
Pincher Creek	-53,820	-9,120	-180					-63,120	-108,819
Namao	-43,728	-23,574	-3,126	-3,126	-3,126	-3,126		-79,806	-137,586
Parkland	-45,540	-9,810						-55,350	-95,423
Lloydminster	+16,896	+12,116	+6,120	+6,120	+6,120			+47,372	+81,669
Vegreville	-23,982	-7,754	+360	+360				-31,016	-53,472
Average loss or gain in carbon	-26,626	-8,808	+1,760	+3,314	+2,658				
Organic matter	-45,903	-15,185	+3,034	+5,713	+4,582				

Considering the total carbon gains or losses in the column at the extreme right of Table XIV, six out of nine fields show total losses varying from 31,016 to 90,900 pounds of carbon or 53,472 to 156,712 pounds of organic matter per acre. Gains of carbon occurred at Edmonton, Melfort and Lloydminster in amounts computed to be 110,184, 12,568 and 81,669 pounds of organic matter per acre, respectively.

In all of this work it should be borne in mind that the analyses of surface samples give the most reliable comparisons, and that natural soil variability affects the comparisons to a greater extent in the cases of the deeper soil layers, and in the comparisons of the total amounts present in greater depths which include the surface soil.

Dark Brown Soils.

The carbon and organic matter figures for samples obtained in the dark brown zone are contained in Tables XV and XVI.

Losses varying from .45 to 1.75 per cent. were found in seven out of nine surface horizons of cultivated soil (Table XV). Gains in two horizons were of a very small order, .02 and .05 per cent. Much smaller losses of from .02 to .23 per cent. were found in six out of nine subsurface layers. Gains are shown at three locations and are .13, .14 and .01 per cent., also quite small. A gain in carbon of .39 per cent. occurred in the only subsoil horizon examined, that of

Table XV. Total organic carbon and loss or gain of organic carbon as per cent. in virgin and cultivated dark brown soils

					Total Organic C		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Per cent.	Av. of duplicate samples	Gain or loss
Morrin	C.	Virgin	457	0-6	5.02		
"	"	"	460	"	4.78	4.90	
"	"	Cult. 26 yrs.	463	"	3.46		
"	"	" "	466	"	3.41	3.44	-1.46
"	"	Virgin	458	6-12	2.25		
"	"	"	461	"	2.09	2.17	
"	"	Cult.	464	"	2.22		
"	"	"	467	"	1.93	2.08	-.09
Edgerton	L.	Virgin	292	0-8	4.46		
"	"	"	296	"	3.95	4.21	
"	"	Cult. 26 yrs.	300	"	3.18		
"	"	" "	303	"	3.65	3.42	-0.79
"	Si.L.	Virgin	294	8-17	1.27		
"	"	"	298	8-21	1.30	1.29	
"	"	Cult.	301	8-20	1.14		
"	"	"	305	"	1.16	1.15	-0.14
Cutknife	L.	Virgin	361	0-7	4.48		
"	"	"	364	"	4.51	4.50	
"	"	Cult. 31 yrs.	367	"	3.02		
"	"	" "	369	"	3.08	3.05	-1.45
"	Si.L.	Virgin	362	7-22	1.09		
"	"	"	365	7-28	0.87	0.98	
"	"	Cult.	368	7-26	0.84		
"	"	"	370	7-22	0.81	0.83	-0.15
Regina (E)	L.	Virgin	405	0-6	4.29		
	"	"	408	"	4.34	4.32	
"	"	Cult. 49 yrs.	411	"	2.61		
"	"	" "	413	"	2.53	2.57	-1.75
"	C.L.	Virgin	406	6-18	1.15		
"	"	"	409	"	1.02	1.09	
"	"	"	412	6-16	0.77		
"	"	"	414	"	0.94	0.86	-0.23

Table XV (Continued)

Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Total Organic C Per cent.	Av. of duplicate samples	Gain or loss
Regina (S)	C.	Virgin	395	0-6	3.34		
	"	"	398	"	3.40	3.37	
"	"	Cult. 50 yrs.	401	"	1.76		
"	"	" "	403	"	1.67	1.72	-1.65
"	"	Virgin	396	6-16	1.44		
"	"	"	399	"	1.60	1.52	
"	"	Cult.	402	"	1.14		
"	"	"	404	"	1.86	1.50	-0.02
Scott	L.	Virgin	351	0-7	3.09		
"	"	"	354	"	3.24	3.17	
"	"	(Cult. 12 yrs.	357	"	3.18		
"	"	(Rot. D	359	"	3.20	3.19	+0.02
"	Si.L.	Virgin	352	7-14	1.02		
"	"	"	355	"	1.11	1.07	
"	"	Cult.	358	"	1.12		
"	"	"	360	"	0.94	1.03	-0.04
Hand Hills	L.	Virgin	17	0-8	2.65		
	"	"	20	"	3.10	2.88	
"	"	Cult. 20 yrs.	23	0-6	3.16		
"	"	" "	26	0-8	2.69	2.93	+0.05
"	C.L.	Virgin	18	8-14	1.35		
"	"	"	21	"	1.33	1.34	
"	"	Cult.	24	6-12	1.60		
"	"	"	27	8-14	1.34	1.47	+0.13
Lethbridge	Si.L.	Virgin	105	0-5	2.65		
	"	"	109	"	2.74	2.70	
"	"	(Rot.U Cult.	113	"	2.29		
"	"	(Irrigated	117	"	2.21	2.25	-0.45
"	"	Virgin	107	5-12	1.71		
"	"	"	111	"	1.58	1.65	
"	"	Cult.	115	5-10	1.81		
"	"	"	119	"	1.77	1.79	+0.14
"	"	Virgin	108	12-18	0.98		
"	"	"	112	"	0.76	0.87	
"	"	Cult.	116	10-16	1.18		
"	"	"	120	"	1.33	1.26	+0.39

Table XV (Continued)

Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Total Organic C		
					Per cent.	Av. of duplicate samples	Gain or loss
Lethbridge	Si.L.	Virgin	439	0-6	2.60		
	"	"	442	"	2.52	2.56	
"	"	(Cult. Rot. C	445	"	1.60		
"	"	(Dry land	448	"	1.52	1.56	-1.00
"	"	Virgin	440	6-18	1.20		
"	"	"	443	"	1.16	1.18	
"	"	Cult.	446	6-12	1.07		
"	"	"	449	"	1.30	1.19	+0.01

Rotation U in Lethbridge. A preponderance of losses have occurred in the surface and subsurface horizons of the cultivated dark brown soils, such losses being much greater and certainly significant in the majority of surface horizons.

The exact magnitude of losses and gains are given on a pounds per acre basis in Table XVI. Losses of carbon in the top 6 inches took place in eight fields out of nine analyzed, one loss being 2,610 pounds, the others ranging between 6,679 and 29,790 pounds per acre. The one gain found in Rotation D, at Scott, was only 450 pounds. The average loss of carbon from the top 6 inches of all dark brown cultivated soils was 17,182 pounds per acre, equivalent to 29,622 pounds of organic matter. These figures represent 26 per cent. of the original carbon or organic matter content.

Table XVI. Loss or gain of organic carbon in cultivated dark brown soils on a pounds per acre basis

	Depth in Inches				Total organic carbon	Total organic matter
Location	0-6	6-12	12-18	18-24		
Morrin	-26,370	-1,710			-28,080	-48,410
Edgerton	-14,220	-5,370	-945		-20,535	-35,402
Cutknife	-26,010	-6,660	-2,790	-2,790	-38,250	-65,943
Regina (E)	-31,410	-4,140	-4,140		-39,690	-68,426
" (S)	-29,790	-360	-360		-30,510	-52,599
Scott	+450	-450				
Hand Hills	-2,610	-830			-3,440	-5,931
Lethbridge-Rot.U	-6,679	-141	+4,620		-2,200	-3,793
" - " C	-18,000	+180			-17,820	-30,722
Average loss or gain in carbon	-17,182	-2,172	-725			
Organic matter	-29,622	-3,746	-1,250			

Again the losses far exceeded the gains in the 6 to 12 inch depth of cultivated soil. Losses were much smaller than occurred in the surface horizons. They varied from 141 to 6,660 pounds in eight cases. The one gain was 180 pounds in Rotation C at Lethbridge. The average loss for the nine duplicate samples was 2,172 pounds of carbon or 3,746 pounds or organic matter per acre, which represents about 11 per cent. of the original content as measured by the carbon content of the virgin sod samples.

Carbon analyses of the 12 to 18 inch depth was made on five fields, four of which show a loss, and one a gain of 4,620 pounds, in Rotation U at Lethbridge. The average loss for the five fields was 725 pounds of carbon, or 1,250 pounds of organic matter.

Losses far outnumber any gains regardless of the depth: twenty-one of the former to three of the latter, when all samples and depths are taken together. A similar picture is presented when the total gains or losses at individual locations is considered. Losses vary from 2,200 to 39,690 pounds of carbon per acre. As organic matter the losses vary from 3,793 to 68,426 pounds per acre. At Scott, Saskatchewan, neither loss nor gain occurred in Rotation D, cultivated for only 12 years.

Brown Soils.

Tables XVII and XVIII contain the data from organic

carbon analyses of samples collected in the brown soil zone.

At seven out of eight locations the difference in per cent. carbon between sod and cultivated surface soils varied from .18 to 2.06 per cent., all in favor of the sod. A gain in carbon occurred in the cultivated surface soil at Swift Current, but this gain was more than offset by a loss of .35 per cent. in the subsurface horizon. Similar results were found in this sample with respect to the nitrogen content.

Six cultivated subsurface horizons lost carbon in amounts varying from .05 to .35 per cent., and two gained carbon, the increases being .02 and .03 per cent.

The cultivated field at Brooks shows neither gain nor loss from the third horizon. A slight gain of .07 per cent. was found at Swift Current (S) in the same horizon.

In the comparison of sod and cultivated brown soil samples, the per cent. carbon figures show that the sod generally contains more carbon than the cultivated fields. Some of the losses, particularly in the subsurface, were of a very small order.

Actual gains or losses of carbon are shown in Table XVIII. Seven out of eight cultivated fields have lost carbon from the surface 6 inches. The range in loss was from 1,350 to 36,990 pounds. A carbon gain of 1,260 pounds occurred at Swift Current. The average loss from the surface 6 inches of the cultivated brown soil samples is 13,080 pounds of

Table XVII. Total organic carbon and loss or gain of organic carbon as per cent. in virgin and cultivated brown soils

					Total Organic C		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Per cent.	Av. of duplicate samples	Gain or loss
Swift Current (S)	L.	Virgin	415	0-6	5.45		
	"	"	419	"	5.24	5.35	
	"	Cult. 30 yrs.	423	"	3.35		
"	"	" "	426	"	3.23	3.29	-2.06
"	"	Virgin	416	6-15	1.33		
"	"	"	420	"	1.20	1.27	
"	"	Cult.	424	6-15	1.35		
"	"	"	427	6-15	1.22	1.29	+0.02
"	Si.L.	Virgin	417	15-30	0.70		
"	"	"	421	15-32	0.82	0.76	
"	"	Cult.	425	16-24	0.78		
"	"	"	428	15-24	0.88	0.83	+0.07
Gros Ventre	L.	Virgin	73	0-6	4.14		
	"	"	77	"	3.97	4.06	
"	"	Cult. 20 yrs.	81	"	2.38		
"	"	" "	85	"	2.25	2.32	-1.74
"	C.L.	Virgin	75	6-20	1.25		
"	"	"	79	"	1.23	1.24	
"	"	Cult.	83	"	0.89		
"	"	"	87	6-24	0.89	0.89	-0.35
Swift Current	L.	Virgin	57	0-6	3.31		
	"	"	61	"	3.68	3.50	
"	"	Cult. 20 yrs.	65	"	3.51		
"	"	" "	69	"	3.62	3.57	+0.07
"	"	Virgin	59	6-18	1.38		
"	"	"	63	"	1.24	1.31	
"	"	Cult.	67	"	0.83		
"	"	"	71	"	1.13	0.98	-0.33
Acadia Valley	C.	Virgin	29	0-6	1.98		
	"	"	32	"	1.57	1.78	
"	"	Cult. 22 yrs.	35	"	1.69		
"	"	" "	38	"	1.71	1.70	-0.08
"	"	Virgin	31	6-8	1.04		
"	"	"	34	"	1.04	1.04	
"	"	Cult.	37	"	0.93		
"	"	"	40	"	0.99	0.96	-0.08

Table XVII (Continued)

Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Total Organic C Per cent.	Av. of duplicate samples	Gain or loss
Cavendish	F.S.L.	Virgin	41	0-5	2.01		
"	"	"	45	"	1.83	1.92	
"	"	Cult. 23 yrs.	49	"	1.45		
"	"	" "	53	"	1.20	1.33	-0.59
"	"	Virgin	43	5-12	1.04		
"	"	"	47	"	1.13	1.09	
"	"	Cult.	51	"	1.19		
"	"	"	55	"	0.89	1.04	-0.05
Brooks	F.S.L.	Virgin	1	0-9	2.22		
"	"	"	5	"	2.14	2.18	
"	"	(Cult. 12 yrs.	9	"	1.35		
"	"	(Irrigated	13	"	1.18	1.27	-0.91
"	"	Virgin	2	9-16	0.89		
"	"	"	6	"	0.73	0.81	
"	"	Cult.	10	"	0.98		
"	"	"	14	"	0.69	0.84	+0.03
"	"	Virgin	3	16-36	0.55		
"	"	"	7	"	0.59	0.57	
"	"	Cult.	11	"	0.64		
"	"	"	15	"	0.50	0.57	0.00
Cabri	C.	Virgin	429	0-7	1.27		
"	"	"	432	"	1.27	1.27	
"	"	Cult. 26 yrs.	435	"	0.87		
"	"	" "	437	"	1.16	1.02	-0.25
"	"	Virgin	430	7-21	0.95		
"	"	"	433	"	0.92	0.94	
"	"	Cult.	436	7-22	0.89		
"	"	"	438	"	0.89	0.89	-0.05
Manyberries	L.	Virgin	89	0-6	1.36		
	"	"	93	"	1.47	1.42	
"	"	Cult. 23 yrs.	97	"	1.15		
"	"	" "	101	"	1.00	1.08	-0.34
"	Si.L.	Virgin	91	6-14	1.00		
"	"	"	95	"	0.93	0.97	
"	"	Cult.	99	"	0.93		
"	"	"	103	"	0.88	0.91	-0.06

carbon, or 22,550 pounds of organic matter. Twenty-seven per cent. of the original carbon and organic matter has been lost.

Table XVIII. Loss or gain of organic carbon in cultivated brown soils on a pounds per acre basis

	Depth in Inches				Total organic carbon	Total organic matter
Location	0-6	6-12	12-18	18-24		
Swift Current (S)	-36,990	+360	+1,095	+1,830	-33,705	-58,107
Gros Ventre	-31,320	-6,300	-6,300		-43,920	-75,718
Swift Current	+ 1,260	-5,940	-5,940		-10,620	-18,309
Acadia Valley	- 1,350				-1,350	-2,327
Cavendish	- 9,060	-810			-9,870	-17,016
Brooks	-16,470	-8,010	+300		-24,180	-41,686
Cabri	-4,590	-1,440	-810		-6,840	-11,792
Manyberries	-6,120	-1,080			-7,200	-12,413
Average loss or gain in carbon	-13,080	-3,317	-2,331			
Organic matter	-22,550	-5,719	-4,019			

Six out of seven 6 to 12 inch depths have lost carbon, the lowest amount, at Cavendish, being 810 pounds per acre, the highest 6,300 pounds per acre, at Gros Ventre. A small gain of 360 pounds is shown at Swift Current (S). The average loss from the 6 to 12 inch depth of seven cultivated fields is 3,317 pounds per acre of carbon, which means 5,719 pounds of organic matter. This loss amounts to 15 per cent. of the original carbon or organic matter content.

Two gains and three losses are shown in the 12 to 18 inch depth of five samples. Apparently the average loss

is over a ton, but this figure is contributed to largely by two samples, Gros Ventre and Swift Current. It is doubtful if this amount of carbon is lost from the 12 to 18 inch depth of brown cultivated soils when the picture is influenced so strongly by the data from only two locations.

The columns at the extreme right hand of Table XVIII show the total loss of carbon and organic matter from each location in cultivated soil. A general loss of carbon has occurred, from 1,350 pounds per acre at Acadia Valley to 43,920 pounds at Gros Ventre. The limits of loss in organic matter were 2,327 and 75,718 pounds per acre.

Gray Transition Soils.

The organic carbon contents of gray transition soil samples are reported in Tables XIX and XX. Only two sets of samples were collected from this soil zone, one at Colinton and one at Grosmont.

A gain in per cent. carbon was found in the cultivated surface horizon at Colinton, but not at Grosmont. A loss in the second and third horizon occurred at Colinton, with neither gain nor loss in the subsurface at Grosmont.

General losses of carbon are shown from all six inch layers of soil in both cultivated fields, except the surface 6 inches at Colinton.

Table XIX. Total organic carbon and loss or gain of organic carbon as per cent. in virgin and cultivated gray transition soils

					Total Organic C		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Per cent.	Av. of duplicate samples	Gain or loss
Colinton	Si.L.	Virgin	238	0-8	1.85		
"	"	"	243	"	2.46	2.16	
"	"	Cult. 20 yrs.	246	0-6	2.12		
"	"	" "	251	"	2.75	2.44	+0.28
"	"	Virgin	239	8-13	0.43		
"	"	"	244	"	0.67	0.55	
"	"	Cult.	248	6-9	0.61		
"	"	"	249	9-13	0.26		
"	"	"	253	6-9	0.30		
"	"	"	254	9-13	0.24	0.34	-0.21
"	C.	Virgin	240	13-25	0.53		
"	"	"	245	"	0.47	0.50	
"	"	Cult.	250	"	0.27		
"	"	"	255	"	0.31	0.29	-0.21
Grosmont	Si.L.	Virgin	327	0-8	1.84		
"	"	"	332	"	1.91	1.88	
"	"	Cult. 27 yrs.	334	"	1.62		
"	"	" "	336	"	1.59	1.61	-0.27
"	C.L.	Virgin	328	8-20	0.43		
"	"	"	333	"	0.54	0.49	
"	"	Cult.	335	"	0.54		
"	"	"	337	"	0.43	0.49	0.00

The total carbon loss at Colinton was 15,840 pounds per acre, at Grosmont 6,480 pounds. As organic matter these losses were 27,308 and 11,172 pounds per acre.

Table XX. Loss or gain of organic carbon in cultivated gray transition soils on a pounds per acre basis

	Depth in Inches				Total	Total
Location	0-6	6-12	12-18	18-24	organic carbon	organic matter
Colinton	+5,130	-13,410	-3,780	-3,790	-15,840	-27,308
Grosmont	-4,860	-1,620			-6,480	-11,172
Average loss or gain in carbon	+135	-7,515				
Organic matter	+233	-12,956				

Gray Soils.

The data from six locations in the gray wooded soil zone are contained in Tables XXI and XXII

Losses ranging from .18 to 1.47 per cent. carbon were found in the plowing depth of all six cultivated fields investigated. Small decreases of .05, .07 and .06 per cent. occurred in the subsurface horizon of three samples, and gains of .02 and .09 per cent. at two locations.

Table XXII contains the losses and gains on a pounds per acre basis. A reduction of from 3,240 to 26,460 pounds of carbon was found in the surface six inches of all six cultivated fields. This means an average loss of 17,400 pounds of carbon or 29,998 pounds of organic matter per acre, which is equal to a 42 per cent. loss of the original.

Table XXI. Total organic carbon and loss or gain of organic carbon as per cent. in virgin and cultivated gray soils.

					Total Organic C		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Per cent.	Av. of duplicate samples	Gain or loss
Breton	Si.L.	Virgin	173	0-7	2.87		
"	"	"	178	"	2.51	2.69	
"	"	(Cult. Ser.C 1	181	"	1.31		
"	"	(Check-	185	"	1.32	1.32	-1.37
"	"	Cult. Ser.C 3)	189	"	1.31		
"	"	Complete)	193	"	1.45	1.38	-1.31
"	C.	Virgin	174	7-60	0.42		
"	"	"	179	"	0.45	0.44	
"	"	Cult.	183	7-64	0.44		
"	"	"	187	"	0.33	0.39	-0.05
"	"	"	191	7-65	0.40		
"	"	"	195	"	0.33	0.37	-0.07
Fallis	Si.L.	Virgin	199	0-7	2.47		
"	"	"	204	"	2.73	2.60	
"	"	Cult. 24 yrs.	206	"	1.13		
"	"	" "	210	"	1.13	1.13	-1.47
"	C.	Virgin	200	7-60	0.50		
"	"	"	205	"	0.49	0.50	
"	"	Cult.	208	7-48	0.47		
"	"	"	212	"	0.41	0.44	-0.06
Tweedsmuir	F.S.L.	Virgin	371	0-7	2.30		
	"	"	374	"	2.31	2.31	
"	"	Cult. 12 yrs.	377	"	1.63		
"	"	" "	379	"	1.72	1.68	-0.63
"	S.L.	Virgin	372	7-36	0.18		
"	"	"	375	"	0.20	0.19	
"	"	Cult.	378	"	0.22		
"	"	"	380	"	0.19	0.21	+0.02
MacKay	Si.L.	Virgin	216	0-7	1.69		
"	"	"	222	"	1.93	1.81	
"	"	(Cult. 5 yrs.	226	"	1.72		
"	"	(Fertilized	229	"	1.54	1.63	-0.18
"	C.	Virgin	217	7-48	0.42		
"	"	"	223	"	0.44	0.43	
"	"	Cult.	228	7-50	0.52		
"	"	"	231	"	0.51	0.52	+0.09
MacKay	Si.L.	Virgin	216	0-7	1.69		
"	"	"	222	"	1.93	1.81	
"	"	(Cult. 3 yrs.	232	"	0.61		
"	"	(No fertilizer	234	"	1.04	0.83	-0.98

Table XXII. Loss or gain of organic carbon in cultivated gray soils on a pounds per acre basis

Location	Depth in Inches						Total organic carbon	Total organic matter
	0-6	6-12	12-18	18-24	24-30	30-48		
Breton - C 1	-24,750	-4,875	-900	-900	-900	-2,700	-35,025	-60,383
" - C 3	-23,580	-4,980	-1,260	-1,260	-1,260	-3,780	-36,120	-62,271
Fallis	-26,460	-5,235	-990	-990	-990	-2,970	-37,635	-64,883
Tweedsmuir	-11,340	-1,665	+270	+270	+270		-12,195	-21,024
MacKay - Fert.	-3,240	+735	+1,530	+1,530	+1,530	+4,590	+6,675	+11,508
" - Non-Fert.	-15,030						-15,030	-25,912
Average loss or gain in carbon	-17,400	-3,204	-270	-270	-270	-1,215		
Organic matter	-29,998	-5,524	-465	-465	-465	-2,095		

The carbon content of the 6 to 12 inch depth has been reduced at four locations out of five. The average loss was 3,204 pounds. In organic matter this reduction amounts to 5,524 pounds per acre, or about 17 per cent. of the original as measured by the corresponding content of virgin soil.

Lower depths at Breton and Fallis show a reduced amount of carbon, while at Tweedsmuir and MacKay there has been an increase in the cultivated. The average losses for these lower depths are small. With only five locations, three of which show losses and two gains, a general statement cannot be made as to whether losses or gains predominate from the 12 inch depth down.

Total losses from five cultivated fields are shown in the right hand columns of Table XXII. Total losses of organic matter ranged from 10 to 32 tons per acre. The cultivated field at MacKay is shown to contain nearly six tons more organic matter than nearby virgin sod.

The relation between years of cultivation and loss of carbon and organic matter

All cultivated black soil samples have been under the plow for just about the same number of years. Despite this fact losses vary considerably in amount so there would

appear to be no direct relation between the length of time of cultivation and loss of organic carbon and organic matter.

In the dark brown belt evidence of greater loss from longer cultivation is brought forth by comparing Scott with Cutknife and the two Regina samples. Rotation D at Scott, cultivated only 12 years, neither lost nor gained carbon, while Cutknife, cultivated 31 years, lost 38,250 pounds and the Regina samples cultivated 49 and 50 years lost 39,690 and 30,510 pounds per acre respectively. Organic matter losses were correspondingly larger.

All cropped brown soil samples have been cultivated for practically the same number of years. Gros Ventre, cultivated only 20 years lost about 22 tons of organic carbon, Swift Current (S) cultivated for 30 years lost about 17 tons. The other samples, cropped for about 25 years, range down from these figures to a loss of only 1,350 pounds per acre.

Similarly the gray transition and gray wooded soil samples present such a varied picture that any definite conclusions regarding the relation of years of cultivation to loss of organic matter cannot be drawn.

The effect of soil class on loss of organic carbon and organic matter

Table XXIII has been drawn up showing the various surface, subsurface, and subsoil classes with the number of

gains and losses occurring in each.

Table XXIII. The number of losses and gains that occurred in each cultivated surface, subsurface and subsoil class.

Soil class	No. of samples	Surface Gains	Surface Losses	Subsurface & Subsoil Gains	Subsurface & Subsoil Losses
Loam	19	3	13	1	2
Silt Loam	22	1	9	7	5
Fine Sandy Loam	6	-	3	1	1
Sandy Loam	1	-	--	1	--
Clays	17	-	4	2	11
Clay Loams	10	-	--	4	5

One clay loam and one fine sandy loam sample included in the column headed "No. of Samples", but not shown otherwise, has neither lost nor gained carbon.

In all surface soil classes there are many more losses than gains regardless of the soil class. So apparently there is no soil class amongst those reported that is not subject to loss, at least when such soil class is considered to the plow depth.

Considering all subsurface and subsoil classes in all classes but the clays there are about as many losses as gains. The clay soils show eleven losses and only two gains, which might make it appear as though this class of soil is more subject to a loss of carbon than other classes. However, eight of the losses found are of a small order, and it is felt that other contributing factors may have a greater bearing

than soil class on nutrient losses. More samples would be necessary before making the definite statement that clay subsurface or subsoils have a greater tendency to lose carbon than other soil classes.

The effect of cropping systems on loss of organic carbon and organic matter

Twenty-seven cultivated fields examined in this work including Rotations C at Lethbridge and Lacombe had grown wheat, oats, and barley chiefly, with a fallow every three or four years. No fertilizer or manure had been applied. Twenty-five of these twenty-seven cultivated fields decreased in carbon content in amounts varying between 1,350 and 90,900 pounds per acre. These figures in pounds per acre of organic matter to the depth analyzed are 2,327 and 156,712. The fields at Lloydminster and Melfort show gains of 51,669 and 12,568 pounds of organic matter per acre respectively.

It may be condluded that a straight grain and fallow system will be conducive to considerable losses of organic carbon.

Seven plots located on experimental farms have been subject to cropping systems other than straight grain and fallow. Six of these seven plots have lost appreciable amounts of organic carbon from the surface 6 inches. One plot, at

Scott, cultivated for 12 years shows a small gain of 450 pounds in the surface 6 inches. Cropping systems practised on the six plots losing organic carbon have not been sufficient to maintain the carbon in the upper 6 inches of soil.

Though the plot at Edmonton lost 24,840 pounds of organic carbon from the surface 6 inches, this deficit has been more than made up at lower depths and the total amount in the cultivated field exceeds the sod by 63,912 pounds, which amounts to over 55 tons of organic matter. The crops grown were chiefly grains, and it is probable that the increase is due, not to the building up of organic matter, but to soil variability.

Rotation O, a seven year rotation at Lacombe consisting of potatoes, wheat, oats, fallow, wheat seeded down with alfalfa and western rye, then two years of hay, has apparently lost more organic matter than Rotation C, a three year rotation of wheat, wheat and fallow. Incidentally Rotation O shows a tremendous reduction in organic matter, if the nearby sod can be used for a fair comparison. Soil variability probably accounts for most of this loss (see page 56). The loss is about 78 tons, or about 1/2 of the original content.

Crops in rotation combined with irrigation have apparently not maintained the carbon content of Rotation U (six years alfalfa, one beets, one wheat, one oats and one

barley) at Lethbridge. The loss to the depth sampled, however, is not large, only 2200 pounds, which is about 1/8 of the loss from Rotation C, consisting of a three year rotation of wheat, wheat and fallow.

Alfalfa and irrigation have not kept up the carbon or organic matter content of the cultivated field at Brooks, the total organic matter loss being nearly 22 tons.

Cultivated plots C 1 (unfertilized) and C 3 (complete fertilizer) at Breton down to the depth sampled have lost considerable amounts of organic carbon, about 18 and 19 tons, respectively. The complete fertilizer has not increased the carbon content apparently. The surface foot of Plot C 3 is higher in carbon than Plot C 1 by one ton, but the 12 to 48 inch depth of Plot C 3 has lost two tons more than the corresponding depth of Plot C 1. Sometimes one sample collected represented quite a depth of soil, and this was the case particularly in the gray wooded soils. A small difference in per cent., when multiplied by a great weight of soil, might accentuate gains or losses.

Summary of carbon determinations

Twenty-nine cultivated fields out of a total of thirty-four at various points in Alberta and Saskatchewan have been decreased in organic matter as a result of cultivation

and cropping. The amounts of organic matter are calculated from the figures for organic carbon, by multiplying by 1.724. Losses to the greatest depth analyzed range from 2,327 pounds at Acadia Valley in the brown zone to 156,712 pounds at Lacombe in the black zone. Increases of organic matter occurred at Edmonton, Melfort and Lloydminster in the black zone and MacKay in the gray wooded zone. Gains were of the order of 56, 6, 41 and 6 tons of organic matter, respectively.

The average loss of organic matter from the 0 to 6 inch depth of the black soils was 45,903 pounds, a loss of 21 per cent. The decrease in the 6 to 12 inch depth was 15,185 pounds, also 21 per cent. of the original content. Though the averages show gains at lower depths, the number of gains and losses are about equal. Large gains at Edmonton, Melfort and Lloydminster are chiefly responsible for the averages being positive.

The loss of organic matter from the surface of the dark brown cultivated soils was 29,622 pounds per acre, a decrease of 26 per cent. The average differences between the 6 to 12 inch depths of sod and cultivated soils is almost two tons of organic matter, in favor of the sod. Cultivation has apparently decreased the organic matter by 11 per cent.

The surface 6 inches of cultivated brown soils have lost 27 per cent. of their organic matter, an average decrease of 22,550 pounds. The organic matter in the 6 to

12 inch depth has been lowered by 11 per cent. or 5,719 pounds per acre.

The surface 6 inches of gray soils have lost 42 per cent. of their original organic matter content, an average of 29,998 pounds per acre. Organic matter in the 6 to 12 inch depth has been decreased by 17 per cent., or 5,524 pounds per acre.

A straight grain and fallow system has not maintained the organic carbon or organic matter content of western Canada prairie soils.

The C:N Ratios of Virgin and Cultivated Soils

C:N ratios were worked out for the cultivated and virgin soils using the figures for the average per cent. nitrogen and average per cent. carbon of duplicate samplings. Table XXIV contains the C:N ratios for surface, subsurface and subsoil samples upon which both nitrogen and carbon had been determined.

With few exceptions the C:N ratio narrows in both virgin and cultivated soils with increase in depth. With respect to a comparison of virgin and cultivated soils the general tendency is a narrowing of the ratio due to cultivation and cropping.

Table XXIV. Carbon to nitrogen ratios in various horizons of virgin and cultivated soils from all soil zones

Location	Virgin or cultivated	Horizons		
		Surface	Subsurface	Subsoil
	Black Soils			
Edmonton	Virgin	12.2	11.3	9.4
"	Cultivated	12.3	12.1	11.0
Melfort	Virgin	12.9	12.7	12.2
"	Cultivated	12.9	11.8	11.5
Lacombe	Virgin	13.1	12.8	16.3
"	Cultivated	13.3	13.4	11.5
"	"	13.1	13.4	13.4
Pincher Creek	Virgin	13.8	11.2	
"	Cultivated	12.5	11.0	
Namao	Virgin	15.0	10.5	10.0
"	Cultivated	13.0	9.7	9.1
Parkland	Virgin	13.7	12.1	
"	Cultivated	12.7	11.5	
Lloydminster	Virgin	13.1	12.1	12.1
"	Cultivated	12.7	11.7	12.0
Vegreville	Virgin	13.3	12.0	
"	Cultivated	13.0	11.2	
	Dark Brown Soils			
Morrin	Virgin	11.9	10.2	
"	Cultivated	10.6	9.5	
Edgerton	Virgin	12.5	11.3	
"	Cultivated	10.5	9.7	
Cutknife	Virgin	13.4	12.6	
"	Cultivated	12.6	13.2	
Regina (E)	Virgin	13.6	12.4	
"	Cultivated	12.8	11.2	
Regina (S)	Virgin	10.8	9.3	
"	Cultivated	9.6	9.7	
Scott	Virgin	12.7	12.2	
"	Cultivated	12.8	11.4	
Hand Hills	Virgin	13.0	12.6	
"	Cultivated	13.1	11.0	
Lethbridge	Virgin	12.6	10.8	10.0
"	Cultivated	11.5	10.5	10.5
Lethbridge	Virgin	12.4	11.6	
"	Cultivated	12.0	10.9	

Table XXIV (Continued)

Location	Virgin or cultivated	Horizons		
		Surface	Subsurface	Subsoil
	Brown Soils			
Swift Current (S)	Virgin	13.6	12.2	12.7
"	Cultivated	12.5	11.3	11.1
Gros Ventre	Virgin	13.9	11.2	
"	Cultivated	12.5	11.4	
Swift Current	Virgin	13.2	11.5	
"	Cultivated	13.2	10.5	
Acadia Valley	Virgin	11.7	10.1	
"	Cultivated	11.0	9.7	
Cavendish	Virgin	12.6	11.0	
"	Cultivated	11.1	9.3	
Brooks	Virgin	13.7	12.9	14.6
"	Cultivated	12.6	11.2	12.1
Cabri	Virgin	9.5	9.4	
"	Cultivated	8.2	9.0	
Manyberries-	Virgin	12.1	11.4	
"	Cultivated	11.3	10.7	
	Gray Transition Soils			
Colinton	Virgin	17.6	16.7	14.3
"	Cultivated	15.6	17.0	14.5
Grosmont	Virgin	13.7	7.9	
"	Cultivated	11.9	8.2	
	Gray Soils			
Breton	Virgin	18.2	13.7	
"	Cultivated	15.7	16.2	
"	"	15.9	14.2	
Fallis	Virgin	19.4	16.7	
"	Cultivated	16.6	13.7	
Tweedsmuir	Virgin	20.3	17.3	
"	Cultivated	21.3	23.4	
MacKay	Virgin	25.2	14.8	
"	Cultivated	21.8	14.4	
"	"	17.7		

Averaging the ratios for all virgin surface samples in the black zone, the figure 13.4 is obtained. Similarly the figure 12.8 is obtained for the surface cultivated soils. The C:N ratio has been narrowed from 13.4 to 12.8 as a result of cultivation and cropping.

Though six out of nine cultivated soils have a narrower ratio in the subsurface than does the sod, the average C:N ratios for sod and cultivated soils is the same, 11.8:1. The C:N ratios of the subsurface cultivated soils at Edmonton and Lacombe are wider than those of the sod.

The third horizon of the sod has an average C:N ratio of 12 and the cultivated soils have an average ratio of 11.4.

A general narrowing of the C:N ratio has occurred in both surface and subsurface cultivated dark brown soils. The average figures are 12.5 for the sod and 11.7 for the cultivated surface horizons and 11.4 and 10.8 for the sod and cultivated subsurface horizons, respectively.

Seven out of eight cultivated fields show a narrower C:N ratio than the sod in the surface and subsurface horizons of the brown soil zone. The average narrowing that has taken place in the surface is from 12.5 in the sod to 11.6 in the cultivated, and from 11.2 in the sod to 10.4 in the cultivated subsurface.

The two sets of gray transition wooded soil samples are different from one another in that the C:N ratio at Grosmont is similar to that of the black soils and much

narrower than at Colinton which is similar to the gray soils. However, the same trend occurs at both locations, a narrower ratio in the surface cultivated soil and a slightly wider one in the subsurface as compared to the sod.

Five out of six surface cultivated soils in the gray wooded zone show a narrower ratio, the average of the surface virgin soils being 20.7, the average of the surface cultivated soils, 18.2. The average figures for the subsurface show the same trend as the subsurface gray transition soils. Cultivation has increased the ratio from 15.6 to 16.4. The analyses of only five subsurface virgin and cultivated samples are contained in the table, three of which show a wider ratio in the cultivated soil and two a wider ratio in the virgin soil. With so few samples and disagreement in the results it cannot be definitely concluded that cultivation of gray wooded soils results in a wider C:N ratio in the subsurface, though the average figures may show this.

Considering all surface soils in all zones, a narrower ratio than in the sod is shown in twenty-seven cultivated fields, and a wider ratio in seven. Lumping all subsurface soils together, twenty-two out of thirty-three cultivated fields have a narrower C:N ratio than the sod. Five of the eleven with a wider ratio occur in the gray wooded or gray transition soils. Seven out of ten subsoils in cultivated fields have a narrower C:N ratio than the corresponding virgin subsoils.

Total Phosphorus Results

Total phosphorus was determined on the samples collected in 1936 only. This permits comparisons between twenty-one sod and an equal number of cultivated locations. Phosphorus figures were obtained for only one location in the gray transition soil zone, and these figures are included in Table XXXI with those for the gray soils.

Black Soils.

In the black soils (Table XXV) four out of six surface horizons show a loss of total phosphorus varying from .010 to 0.22 per cent. The gains shown at Lacombe and Namao were .004 and .002 per cent. Thus there is an indication that phosphorus is lost in some cases from the surface horizons of black soils. Gains in phosphorus of from .002 to .014 per cent. occurred in four out of six subsurface horizons. Losses of .008 and .019 per cent. were found at Pincher Creek and Vegreville, respectively.

Losses or gains of phosphorus from 6 inch depths are presented in Table XXVI. Five out of six cultivated fields have lost phosphorus from the surface 6 inches, and two of the losses have been quite large, 405 pounds at Parkland and 610 pounds at Vegreville. The single gain was 72 pounds at Lacombe (Rotation C). The average loss from the surface 6 inches of the black soils is shown to be 223

Table XXV. Total phosphorus and loss or gain of phosphorus as per cent. in virgin and cultivated black soils

					Total P		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Per cent.	Av. of duplicate samples	Gain or loss
Edmonton	L.	Virgin	307	0-7	.136		
"	"	"	312	"	.146	.141	
"	"	(Cult. 20 yrs.	317	"	.136		
"	"	(Plot A 1	321	"	.126	.131	-.010
"	Si.L.	Virgin	309	7-18	.102		
"	"	"	314	"	.110	.106	
"	"	Cult.	319	7-17	.125		
"	"	"	323	"	.114	.120	+.014
Lacombe	L.	Virgin	153	0-6	.114		
"	"	"	158	"	.116	.115	
"	"	(Cult. 25 yrs.	163	"	.117		
"	"	(Rot. C	167	"	.121	.119	+.004
"	"	Virgin	155	6-15	.116		
"	"	"	160	"	.120	.118	
"	"	Cult. Rot. C	165	"	.114		
"	"	" "	169	"	.125	.120	+.002
Pincher Creek	Si.L.	Virgin	121	0-7	.119		
	"	"	125	"	.111	.115	
"	"	Cult. 27 yrs.	129	"	.099		
"	"	" "	133	"	.110	.105	-.010
"	C.	Virgin	123	7-22	.066		
"	"	"	127	"	.064	.065	
"	"	Cult.	131	"	.055		
"	"	"	135	"	.058	.057	-.008
Namao	L.	Virgin	256	0-9	.134		
"	"	"	261	"	.128	.131	
"	"	Cult. 30 yrs.	266	"	.131		
"	"	" "	271	0-8	.134	.133	+.002
"	C.	Virgin	258	9-15	.069		
"	"	"	263	"	.064	.067	
"	"	Cult.	268	9-12	.080		
"	"	"	273	8-12	.071	.076	+.009

Table XXV (Continued)

					Total P		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Per cent.	Av. of duplicate samples	Gain or loss
Parkland	L.	Virgin	137	0-6	.100		
"	"	"	141	"	.094	.097	
"	"	Cult. 27 yrs.	145	"	.073		
"	"	" "	149	"	.076	.075	-.022
"	C.L.	Virgin	139	6-20	.060		
"	"	"	143	6-16	.068	.064	
"	"	Cult.	147	6-14	.066		
"	"	"	151	6-13	.074	.070	+.006
Vegreville	L.	Virgin	276	0-8	.139		
	"	"	280	"	.134	.137	
"	"	Cult. 30 yrs.	284	0-6	.125		
"	"	" "	288	"	.116	.121	-.016
"	C.L.	Virgin	278	8-26	.066		
"	"	"	282	8-34	.070	.068	
"	"	Cult.	286	6-26	.054		
"	"	"	290	6-27	.044	.049	-.019

pounds or 10 per cent. of the phosphorus content of the virgin soils. In the 6 to 12 inch depth of the cultivated gains have been sufficient in two instances to compensate for the losses that occurred in the surface 6 inches, (Edmonton and Namao). Thus in the 6 to 12 inch depth there were four gains and two losses. The average figure for this depth is a loss of 35 pounds in the cultivated, due largely to the loss of 431 pounds that occurred at Vegreville.

Table XXVI. Loss or gain of phosphorus in cultivated black soils on a pounds per acre basis

Location	Depth in Inches 0-6	6-12	12-18	18-24	Total loss or gain
Edmonton	-180	+173	+243		+236
Lacombe - Rot.C	+72	+28			+100
Pincher Creek	-180	-150	-144	-144	-618
Namao	-36	+63			+27
Parkland	-405	+108			-297
Vegreville	-610	-431	-342	-342	-1725
Average loss or gain	-223	-35			

The total gains or losses from each individual location are shown in the right hand column of Table XXVI. The number of increases and decreases are equal, three of each. Two losses are quite large, 618 pounds per acre at Pincher Creek, and 1,725 pounds at Vegreville. The gains and large losses are probably due to soil variability.

Table XXVII. Total phosphorus and loss or gain of phosphorus as per cent. in virgin and cultivated dark brown soils

					Total P		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Per cent.	Av. of duplicate samples	Gain or loss
Edgerton	L.	Virgin	292	0-8	.080		
"	"	"	296	"	.087	.084	
"	"	Cult. 26 yrs.	300	"	.081		
"	"	" "	303	"	.086	.084	0.0
"	Si.L.	Virgin	294	8-17	.058		
"	"	"	298	8-21	.062	.060	
"	"	Cult.	301	8-20	.070		
"	"	"	305	"	.064	.067	+.007
Hand Hills	L.	Virgin	17	0-8	.063		
	"	"	20	"	.053	.058	
"	"	Cult. 20 yrs.	23	0-6	.052		
"	"	" "	26	0-8	.065	.059	+.001
"	C.L.	Virgin	18	8-14	.041		
"	"	"	21	"	.042	.042	
"	"	Cult.	24	6-12	.062		
"	"	"	27	8-14	.054	.058	+.016
Lethbridge	Si.L.	Virgin	105	0-5	.071		
	"	"	109	"	.074	.073	
"	"	(Cult. Rot. U	113	"	.075		
"	"	(Irrigated	117	"	.070	.073	0.0
"	"	Virgin	107	5-12	.062		
"	"	"	111	"	.064	.063	
"	"	Cult.	115	5-10	.068		
"	"	"	119	"	.068	.068	+.005

Dark Brown Soils.

Only three locations sampled in 1936 were in the dark brown zone. These fields were near Edgerton, Hand Hills and Lethbridge. The differences in per cent. phosphorus between sod and cultivated fields (Table XXVII) show no loss in any horizon of the cultivated. At Edgerton and Lethbridge neither loss nor gain occurred in the surface horizon. Small increases are shown in all three subsurface horizons of cultivated soil.

Table XXVIII. Loss or gain of phosphorus in cultivated dark brown soils on a pounds per acre basis

	Depth in Inches			Total loss
Location	0-6	6-12	12-18	or gain
Edgerton		+84	+126	+210
Hand Hills	+33	+209		+242
Lethbridge - Rot. U	+15	+ 90		+105
Average loss or gain	+24	+128		

These gains in phosphorus in cultivated soils are shown on a pounds per acre basis in Table XXVIII. Increases of phosphorus were found in every 6 inch depth except the surface 6 inches at Edgerton. Though the cultivated soils are slightly higher in phosphorus content than the virgin soils, no definite conclusions can be drawn from the analysis of only three samples. It will be seen that the increases of phosphorus in the cultivated soils are of about the same order

as individual differences between duplicate samples of either sod or cultivated soils (see sample numbers 17 and 20, and again 23 and 26, Table XXVII).

Brown Soils.

Table XXIX shows that out of six surface horizons of the brown soils three have lost phosphorus. These three losses are .015, .020 and .005 per cent. Gains of .012 and .002 per cent. occurred in two instances, while at Acadia Valley neither loss nor gain was found. Two losses of .001 per cent., a gain of .002 per cent. and neither loss nor gain at three other locations were found in the subsurface horizons of the brown soils

Gains in five horizons, losses in three, and neither loss nor gain in four horizons indicates neither a general gain nor loss from the surface or subsurface horizons of cultivated brown soils.

A consideration of Table XXX will show the gains or losses of phosphorus in pounds per acre from the various samples in 6 inch depths. Three gains and three losses are shown in the surface 6 inches. The average loss was 78 pounds per acre, but this figure means little since gains and losses occurred with equal frequency.

In the 6 to 12 inch depth losses outnumber gains by four to one. However, losses that occurred at three locations were only nine pounds.

Table XXIX. Total phosphorus and loss or gain of phosphorus as per cent. in virgin and cultivated brown soils

					Total P		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Per cent.	Av. of duplicate samples	Gain or loss
Gros	L.	Virgin	73	0-6	.082		
Ventre	"	"	77	"	.091	.087	
"	"	Cult. 20 yrs.	81	"	.073		
"	"	" "	85	"	.070	.072	-.015
"	C.L.	Virgin	75	6-20	.072		
"	"	"	79	"	.072	.072	
"	"	Cult.	83	"	.070		
"	"	"	87	6-24	.073	.072	0.0
Swift	L.	Virgin	57	0-6	.069		
Current	"	"	61	"	.066	.068	
"	"	Cult. 20 yrs.	65	"	.082		
"	"	" "	69	"	.077	.080	+.012
"	"	Virgin	59	6-18	.066		
"	"	"	63	"	.064	.065	
"	"	Cult.	67	"	.068		
"	"	"	71	"	.061	.065	0.0
Acadia	C.	Virgin	29	0-6	.072		
Valley	"	"	32	"	.067	.070	
"	"	Cult. 22 yrs.	35	"	.065		
"	"	" "	38	"	.075	.070	0.0
"	"	Virgin	31	6-8	.066		
"	"	"	34	"	.063	.065	
"	"	Cult.	37	"	.062		
"	"	"	40	"	.066	.064	-.001
Cavendish	F.S.L.	Virgin	41	0-5	.056		
"	"	"	45	"	.049	.053	
"	"	Cult. 23 yrs.	49	"	.052		
"	"	" "	53	"	.057	.055	+.002
"	"	Virgin	43	5-12	.055		
"	"	"	47	"	.057	.056	
"	"	Cult.	51	"	.058		
"	"	"	55	"	.058	.058	+.002

Table XXIX (Continued)

Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Total P Per cent.	Total P Av. of duplicate samples	Total P Gain or loss
Brooks	F.S.L.	Virgin	1	0-9	.053		
"	"	"	5	"	.064	.059	
"	"	(Cult.	9	.036			
"	"	(Irrigated	13	"	.041	.039	-.020
"	"	Virgin	2	9-16	.044		
"	"	"	6	"	.042	.043	
"	"	Cult.	10	"	.045		
"	"	"	14	"	.039	.042	-.001
Many-berries	L.	Virgin	89	0-6	.060		
"	"	"	93	"	.060	.060	
"	"	Cult. 23 yrs.	97	"	.054		
"	"	" "	101	"	.055	.055	-.005
"	Si.L.	Virgin	91	6-14	.063		
"	"	"	95	"	.055	.059	
"	"	Cult.	99	"	.059		
"	"	"	103	"	.058	.059	0.0

Total losses at Gros Ventre, Brooks, and Manyberries were 288, 567 and 108 pounds per acre respectively. The first two are probably significant. Gains of 198, 9 and 72 pounds per acre occurred at Swift Current, Acadia Valley and Cavendish.

Table XXX. Loss or gain of phosphorus in cultivated brown soils on a pounds per acre basis

	Depth in Inches			Total loss or gain
Location	0-6	6-12	12-18	
Swift Current	+216	-9	-9	+198
Gros Ventre	-270	-9	-9	-288
Acadia Valley	+9			+9
Cavendish	+36	+36		+72
Brooks	-360	-189	-18	-567
Manyberries	-99	-9		-108
Average loss or gain	-78	-36		

The analytical data show losses of phosphorus in some cases. Phosphorus must have been removed from the soil to some extent by crops and also in some instances losses have no doubt occurred through other causes. However, due to the natural variation in the phosphorus content of soils and to any experimental error involved in determining phosphorus, losses have not been shown from all locations.

Gray Wooded Soils.

Tables XXXI and XXXII contain the data on phosphorus for one gray transition wooded soil profile from Colinton,

and five gray wooded profiles.

The cultivated field at Colinton shows a higher content of phosphorus than the virgin sod both in per cent. and pounds per acre figures and in both surface and subsurface. The total increase is 90 pounds per acre.

The surface horizons of four out of five cultivated fields in the gray soils have less phosphorus than the sod. The differences vary from .004 to .014 per cent. Losses occurred in the lower horizons of two cultivated fields at Breton and one at Fallis. A gain is shown in the surface and subsurface horizons at MacKay, where gains in both nitrogen and organic carbon have been shown previously.

The surface 6 inches of the cultivated fields at Breton and Fallis and of the unfertilized field at MacKay are lower in phosphorus content than the corresponding virgin sod. The average gain of 11 pounds shown for all fields is entirely misleading. Losses predominate but a gain of 558 pounds of phosphorus in the surface of the fertilized field at MacKay has indicated a gain. The average loss, with this MacKay sample excluded, is about 138 pounds.

Losses occurred in the lower depths at Breton and Fallis and gains at MacKay.

Total losses shown in the two Breton plots and at Fallis are of quite a large order. It should be pointed out again here that small differences in per cent. at lower depths

Table XXXI. Total phosphorus and loss or gain of phosphorus as per cent. in virgin and cultivated gray transition and gray wooded soils

					Total P		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Per cent.	Av. of duplicate samples	Gain or loss
Colinton	Si.L.	Virgin	238	0-8	.061		
"	" "	"	243	"	.072	.067	
"	"	Cult. 20 yrs.	246	0-6	.075		
"	"	" "	251	"	.075	.075	+.008
"	"	Virgin	239	8-13	.042		
"	"	"	244	"	.048	.045	
"	"	Cult.	248	6-9	.056		
"	"	"	249	9-13	.040		
"	"	"	253	6-9	.048		
"	"	"	254	9-13	.044	.047	+.002
Breton	Si.L.	Virgin	173	0-7	.070		
"	"	"	178	"	.081	.076	
"	"	(Cult. Ser.C 1	181	"	.070		
"	"	(Check	185	"	.074	.072	-.004
"	"	Cult. Ser. C3)	189	"	.070		
"	"	Complete)	193	"	.073	.072	-.004
"	C.	Virgin	174	7-60	.076		
"	"	"	179	"	.057	.067	
"	"	Cult.	183	7-64	.068		
"	"	"	187	"	.058	.063	-.004
"	"	"	191	7-65	.060		
"	"	"	195	"	.061	.061	-.006
Fallis	Si.L.	Virgin	199	0-7	.067		
"	"	"	204	"	.070	.069	
"	"	Cult. 24 yrs.	206	"	.057		
"	"	" "	210	"	.062	.060	-.009
"	C.	Virgin	200	7-60	.061		
"	"	"	205	"	.060	.061	
"	"	Cult.	208	7-48	.055		
"	"	"	212	"	.060	.058	-.003
MacKay	Si.L.	Virgin	216	0-7	.093		
"	"	"	222	"	.098	.096	
"	"	(Cult. 5 yrs.	226	"	.114		
"	"	(Fertilized	229	"	.139	.127	+.031
"	"	Cult. 3 yrs.)	232	"	.083		
"	"	No Fert.)	234	"	.080	.082	-.014
"	C.	Virgin	217	7-48	.067		
"	"	"	223	"	.070	.069	
"	"	Cult.	228	"	.067		
"	"	"	231	7-50	.074	.071	+.002

are magnified when multiplied out by the weight of several feet of soil to get the number of pounds of phosphorus per acre.

Table XXXII. Loss or gain of phosphorus in cultivated gray transition and gray wooded soils on a pounds per acre basis

	Depth in Inches			Total loss or gain
Location	0-6	6-12	12-48	
Colinton	+50	+40		+90
Breton - C 1	-64	-63	-378	-505
" - C 3	-72	-102	-648	-822
Fallis	-162	-72	-324	-558
MacKay - Fert.	+558	+123	+216	+897
" - No Fert.	-252			-252
Average loss or gain	+11	-15	-284	

Though decreases of phosphorus in cultivated gray soils predominate in the samples examined, more data would have to be gathered before the exact extent of losses could be definitely established.

Summary of phosphorus determinations

To the depth analyzed the number of losses of phosphorus in the cultivated fields from all soil zones is ten and the number of gains is eleven. This is almost an exact balance in number of gains and losses, but the individual losses are in most cases of a much greater order than the

gains.

The average loss from the surface 6 inches of the black soils was 223 pounds, or 10 per cent. of the original phosphorus content. There was a total loss of phosphorus at three locations and a total gain at three others.

The three cultivated dark brown soils contained slightly more phosphorus than the corresponding sod. One half of the cultivated brown soils examined show increases in phosphorus and one half show losses.

More losses than gains were found in cultivated gray wooded soils.

Easily Soluble Phosphorus Determinations

The term "easily soluble phosphorus" applies to that fraction of the total phosphorus in a soil extracted in a sulfuric acid solution buffered to a pH of 3. Easily soluble phosphorus was determined on the samples collected in 1936, and the results are reported in parts per million and pounds per acre in Tables XXXIII to XL inclusive. An analysis was made of the surface and subsurface samples only.

Black Soils.

The surface and subsurface of the cultivated soil at Edmonton and the surface at Pincher Creek and Parkland

Table XXXIII. The easily soluble phosphorus content and the difference in easily soluble phosphorus (expressed in P.P.M.) of virgin and cultivated black soils

					Easily Soluble P		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	P.P.M.	Av. of duplicate samples	Increase or decrease
Edmonton	L.	Virgin	307	0-7	46.4		
"	"	"	312	"	120.0	83.2	
"	"	(Cult. 20 yrs.	317	"	43.2		
"	"	(Plot A 1	321	"	38.3	40.8	-42.4
"	Si.L.	Virgin	309	7-18	56.0		
"	"	"	314	"	37.2	46.6	
"	"	Cult.	319	7-17	38.3		
"	"	"	323	"	28.0	33.2	-13.4
Lacombe	L.	Virgin	153	0-6	8.8		
"	"	"	158	"	13.2	11.0	
"	"	(Cult. 25 yrs.	163	"	20.0		
"	"	(Rot. C	167	"	23.2	21.6	+10.6
"	"	Virgin	155	6-15	5.6		
"	"	"	160	"	8.8	7.2	
"	"	Cult. Rot.C	165	"	20.2		
"	"	" "	169	"	21.8	21.0	+13.8
Pincher Creek	Si.L.	Virgin	121	0-7	20.2		
	"	"	125	"	18.8	19.5	
"	"	Cult. 27 yrs.	129	"	19.2		
"	"	" "	133	"	16.4	17.8	- 1.7
"	C.	Virgin	123	7-22	5.6		
"	"	"	127	"	11.8	8.7	
"	"	Cult.	131	"	5.2		
"	"	"	135	"	25.8	15.5	+ 6.8
Namao	L.	Virgin	256	0-9	68.8		
"	"	"	261	"	72.0	70.4	
"	"	Cult. 30 yrs.	266	"	83.2		
"	"	" "	271	0-8	92.8	88.0	+17.6
"	C.	Virgin	258	9-15	43.2		
"	"	"	263	"	72.0	57.6	
"	"	Cult.	268	9-12	96.0		
"	"	"	273	8-12	48.6	72.3	+14.7

Table XXXIII (Continued)

					Easily Soluble P		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	P.P.M.	Av. of duplicate samples	Increase or decrease
Parkland	L.	Virgin	137	0-6	20.0		
"	"	"	141	"	18.8	19.4	
"	"	Cult. 27 yrs.	145	"	6.6		
"	"	" "	149	"	8.8	7.7	-11.7
"	C.L.	Virgin	139	6-20	3.6		
"	"	"	143	6-16	Trace	1.8	
"	"	Cult.	147	6-14	5.2		
"	"	"	151	6-13	4.0	4.6	+ 2.8
Vegreville	L.	Virgin	276	0-8	24.8		
	"	"	280	"	33.2	29.0	
"	"	Cult. 30 yrs.	284	0-6	49.6		
"	"	" "	288	"	35.2	42.4	+13.4
"	C.L.	Virgin	278	8-26	20.0		
"	"	"	282	8-34	26.4	23.2	
"	"	Cult.	286	6-26	27.6		
"	"	"	290	6-27	44.4	36.0	+12.8

contained less easily soluble phosphorus than the sod. These decreases are from 1.7 p.p.m. at Pincher Creek to 42.4 p.p.m. at Edmonton. Considering all cultivated surface and sub-surface horizons, smaller amounts occurred in only four out of twelve as compared to the sod. The indication from these figures is that there is more easily soluble phosphorus in cultivated black soils than virgin soils.

The parts per million of easily soluble phosphorus in the black soils are expressed in pounds per acre in Table XXXIV. The 0 to 6 inch depths at three locations show less easily soluble phosphorus than the sod, and three locations show more. There is more easily soluble phosphorus in the 6 to 12 inch depth than in the 0 to 6 inch depth of cultivated soils. Taking all locations and depths as a whole, cultivated soils show eleven increases and five decreases. The cultivated soils appear to have more easily soluble phosphorus than the sod, particularly in lower depths.

Table XXXIV. Increase or decrease of easily soluble phosphorus in cultivated black soils on a pounds per acre basis

Location	Depth in Inches 0-6	6-12	12-18	18-24	Increase or decrease
Edmonton	-76	-33	-24		-133
Lacombe - Rot. C	+19	+24			+43
Pincher Creek	-4	+12	+12		+20
Namao	+28	+26			+54
Parkland	-21	+6			-15
Vegreville	+21	+22	+23	+23	+89
Average increase or decrease	-5.5	+9.5			

Table XXXV. The easily soluble phosphorus content and the difference in easily soluble phosphorus (expressed in P.P.M.) of virgin and cultivated dark brown soils

Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Easily Soluble P P.P.M.	 Av. of duplicate samples	 Increase or decrease
Edgerton	L.	Virgin	292	0-8	42.4		
"	"	"	296	"	24.8	33.6	
"	"	Cult. 26 yrs.	300	"	85.6		
"	"	" "	303	"	80.0	82.8	+49.2
"	Si.L.	Virgin	294	8-17	46.0		
"	"	"	298	8-21	24.0	35.0	
"	"	Cult.	301	8-20	51.6		
"	"	"	305	"	53.6	52.6	+17.6
Hand Hills	L.	Virgin	17	0-8	Trace		
	"	"	20	"	3.6	1.8	
"	"	Cult. 20 yrs.	23	0-6	6.0		
"	"	" "	26	0-8	5.2	5.6	+ 3.8
"	C.L.	Virgin	18	8-14	3.6		
"	"	"	21	"	4.4	4.0	
"	"	Cult.	24	6-12	4.0		
"	"	"	27	8-14	8.0	6.0	+ 2.0
Lethbridge	Si.L.	Virgin	105	0-5	15.6		
	"	"	109	"	19.2	17.4	
"	"	(Cult. Rot. U	113	"	16.0		
"	"	(Irrigated	117	"	21.6	18.8	+ 1.4
"	"	Virgin	107	5-12	18.0		
"	"	"	111	"	24.6	21.3	
"	"	Cult.	115	5-10	16.0		
"	"	"	119	"	13.2	14.6	- 6.7

Four out of six cultivated black soils, to the depth analyzed, have more easily soluble phosphorus than the sod.

Dark Brown Soils.

More easily soluble phosphorus is evident in all horizons of the cultivated dark brown soil samples, except at Lethbridge where there was a loss of 6.7 p.p.m. from the subsurface horizon.

Increases or decreases of easily soluble phosphorus on a pounds per acre basis as shown in Table XXXVI indicate a greater content in all depths of the cultivated soils at Edgerton and Hand Hills. At Lethbridge neither increase nor decrease occurs in the surface 6 inches, and a loss of 12 pounds was found in the 6 to 12 inch depth. Though there is more easily soluble phosphorus in two cultivated fields, the analysis of only three locations from the dark brown soils does not permit a definite statement as to general increase or decrease in cropped soils as a result of cultivation.

Table XXXVI. Increase or decrease of easily soluble phosphorus in cultivated dark brown soils on a pounds per acre basis

	Depth in Inches			Increase or
Location	0-6	6-12	12-18	decrease
Edgerton	+89	+50	+30	+169
Hand Hills	+7	+4		+11
Lethbridge - Rot. U	--	-12		-12
Average increase or decrease	+48	+14		

Brown Soils.

The cultivated brown soil samples show just the reverse of what occurred in the black soils. Five out of six cultivated surface horizons show fewer parts per million of easily soluble phosphorus. Two subsurface horizons had more phosphorus, three less, and one had the same content as the sod. Considering all horizons there are more decreases than increases in the cultivated soil.

The easily soluble phosphorus on a pounds per acre basis (Table XXXVIII) follows the same trend as occurred when expressed in parts per million. Five out of six cultivated fields have less phosphorus than the sod in the surface 6 inches. Taking all locations and depths together there are nine decreases, four increases and in one instance neither increase nor decrease. Seven out of the nine decreases are of very small amounts, from 2 to 6 pounds per acre.

The average decrease in the surface six inches of cultivated brown soils is 19 pounds per acre. In the right hand column of Table XXXVIII it can be seen that the surface and subsurface horizons of two out of six cultivated fields have more easily soluble phosphorus than the sod, and the remaining four fields have less. One decrease in easily soluble phosphorus was only 1 pound. The cultivated brown soils seem to have less easily soluble phosphorus than the virgin soils, though some of the differences are very small.

Table XXXVII. The easily soluble phosphorus content and the difference in easily soluble phosphorus (expressed in P.P.M.) of virgin and cultivated brown soils

					Easily Soluble P		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	P.P.M.	Av. of duplicate samples	Increase or decrease
Gros	L.	Virgin	73	0-6	7.6		
Ventre	"	"	77	"	6.8	7.2	
"	"	Cult. 20 yrs.	81	"	4.0		
"	"	" "	85	"	6.0	5.0	- 2.2
"	C.L.	Virgin	75	6-20	7.2		
"	"	"	79	"	8.0	7.6	
"	"	Cult.	83	"	12.0		
"	"	"	87	6-24	20.8	16.4	+ 8.8
Swift	L.	Virgin	57	0-6	27.6		
Current	"	"	61	"	30.4	29.0	
"	"	Cult. 20 yrs.	65	"	7.6		
"	"	" "	69	"	8.0	7.8	-21.2
"	"	Virgin	59	6-18	6.0		
"	"	"	63	"	11.6	8.8	
"	"	Cult.	67	"	8.4		
"	"	"	71	"	6.0	7.2	- 1.6
Acadia	C.	Virgin	29	0-6	74.4		
Valley	"	"	32	"	140.3	107.4	
"	"	Cult. 22 yrs.	35	"	70.4		
"	"	" "	38	"	65.6	68.0	-39.4
"	"	Virgin	31	6-8	80.0		
"	"	"	34	"	89.8	84.9	
"	"	Cult.	37	"	49.6		
"	"	"	40	"	40.0	44.8	-40.1
Cavendish	F.S.L.	Virgin	41	0-5	8.4		
"	"	"	45	"	8.0	8.2	
"	"	Cult. 23 yrs.	49	"	9.6		
"	"	" "	53	"	4.0	6.8	- 1.4
"	"	Virgin	43	5-12	6.8		
"	"	"	47	"	8.4	7.6	
"	"	Cult.	51	"	4.8		
"	"	"	55	"	11.2	8.0	+ 0.4

Table XXXVII (Continued)

					Easily Soluble P		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	P.P.M.	Av. of duplicate samples	Increas or decreas
Brooks	F.S.L.	Virgin	1	0-9	6.4		
"	"	"	5	"	Trace	3.2	
"	"	(Cult.	9	"	Trace		
"	"	(Irrigated	13	"	4.0	2.0	- 1.2
"	"	Virgin	2	9-16	6.0		
"	"	"	6	"	5.6	5.8	
"	"	Cult.	10	"	Trace		
"	"	"	14	"	5.2	2.6	- 3.2
Many-berries	L.	Virgin	89	0-6	4.8		
	"	"	93	"	4.4	4.6	
"	"	Cult. 23 yrs.	97	"	8.4		
"	"	" "	101	"	5.6	7.0	+ 2.4
"	Si.L.	Virgin	91	6-14	9.6		
"	"	"	95	"	6.0	7.8	
"	"	"	99	"	6.8		
"	"	"	103	"	8.8	7.8	0.0

Table XXXVIII. Increase or decrease of easily soluble phosphorus in cultivated brown soils on a pounds per acre basis

	Depth in Inches			Increase or decrease
Location	0-6	6-12	12-18	
Swift Current	-38	-3	-3	-44
Gros Ventre	-4	+18	+18	+32
Acadia Valley	-71			-71
Cavendish	-2	+1		-1
Brooks	-3	-4	-6	-13
Manyberries	+5			+5
Average increase or decrease	-19	+3		

Gray Soils.

Decreases in the cultivated of from 1.3 to 7.3 p.p.m. of easily soluble phosphorus occurred in four out of six comparisons included in Table XXXIX, all in the surface horizon. The subsurface horizon contains more phosphorus in every instance.

The increases or decreases of easily soluble phosphorus in pounds per acre in the cultivated fields are shown in Table XL. Colinton, Breton Plot C 1, and the non fertilized field at MacKay have less easily soluble phosphorus in the surface 6 inches. The Breton Plot C 3, Fallis, and the fertilized field at MacKay have more. Increases occurred in lower depths of the cultivated except in Plot C 1 at Breton.

Table XXXIX. The easily soluble phosphorus content and the difference in easily soluble phosphorus (expressed in P.P.M.) of virgin and cultivated gray transition and gray wooded soils

					Easily Soluble P		
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	P.P.M.	Av. of duplicate samples	Increase or decrease
Colinton	Si.L.	Virgin	238	0-8	9.8		
"	"	"	243	"	30.0	19.9	
"	"	Cult. 20 yrs.	246	0-6	15.0		
"	"	" "	251	"	10.2	12.6	- 7.3
"	"	Virgin	239	8-13	5.0		
"	"	"	244	"	4.4	4.7	
"	"	Cult.	248	6-9	8.8		
"	"	"	249	9-13	6.0		
"	"	"	253	6-9	7.0		
"	"	"	254	9-13	12.6	8.6	+ 3.9
Breton	Si.L.	Virgin	173	0-7	11.4		
"	"	"	178	"	21.2	16.3	
"	"	(Cult. Ser.C 1	181	"	16.0		
"	"	(Check	185	"	14.0	15.0	- 1.3
"	"	Cult. Ser.C 3)	189	"	16.0		
"	"	Complete)	193	"	20.8	18.4	+ 2.1
"	C.	Virgin	174	7-60	7.2		
"	"	"	179	"	11.0	9.1	
"	"	Cult. C 1	183	7-64	7.2		
"	"	" "	187	"	8.0	7.6	- 1.5
"	"	Cult. C 3	191	7-65	22.2		
"	"	" "	195	"	21.2	21.7	+12.6
Fallis	Si.L.	Virgin	199	0-7	59.2		
"	"	"	204	"	30.0	44.6	
"	"	Cult. 24 yrs.	206	"	46.4		
"	"	" "	210	"	48.8	47.6	+ 3.0
"	C.	Virgin	200	7-60	20.0		
"	"	"	205	"	50.8	35.4	
"	"	Cult.	208	7-48	71.2		
"	"	"	212	"	73.6	72.4	+37.0
MacKay	Si.L.	Virgin	216	0-7	51.2		
"	"	"	222	"	43.2	47.2	
"	"	(Cult. 5 yrs.	226	"	84.8		
"	"	(Fertilized	229	"	99.2	92.0	+44.8
"	"	Cult. 3 yrs.)	232	"	36.8		
"	"	No fertilizer)	234	"	30.4	33.6	-13.6
"	C.	Virgin	217	7-48	13.6		
"	"	"	223	"	14.4	14.0	
"	"	Cult.	228	"	29.6		
"	"	"	231	7-50	36.8	33.2	+19.2

Table XL. Increase or decrease of easily soluble phosphorus in cultivated gray transition and gray wooded soils on a pounds per acre basis

Location	Depth in Inches			Increase or decrease
	0-6	6-12	12-48	
Colinton	-15	+2		-13
Breton C 1	-2	-3	-16	-21
" C 3	+5	+24	+136	+165
Fallis	+6	+66	+390	+462
MacKay - Fert.	+81	+43	+206	+330
" - No Fert.	-24			-24
Average increase or decrease	+8.5	+26	+179	

Easily soluble phosphorus figures shown in the right hand column of Table XL indicate small decreases at Colinton, Plot C 1 at Breton, and in the surface 6 inches of the non fertilized field at MacKay. Very large increases are evident in Plot C 3 at Breton, at Fallis, and in the fertilized field at MacKay. More data would have to be gathered before stating definitely that cultivated and cropped fields in the transition gray and gray wooded soil zones have more or less easily soluble phosphorus than nearby virgin sod.

Summary of easily soluble phosphorus determinations

Six out of a total of nine cultivated black and dark brown soils contained more easily soluble phosphorus than

the sod.

Four out of six cultivated brown soils had less easily soluble phosphorus than the sod, while five out of six had less in the surface 6 inches.

Small decreases of phosphorus occurred in one gray transition and two cultivated gray wooded soils. Three cultivated gray wooded soils showed appreciably more easily soluble phosphorus than the corresponding nearby sod.

Analyses of samples from twenty-one locations from all soil zones show more easily soluble phosphorus in eleven cultivated fields and less in ten.

Too few samples have been reported on within each belt to state definitely to what extent cultivation and cropping cause increases or decreases in easily soluble phosphorus.

Nitrification Results

The availability of the nitrogen in the cultivated and uncultivated soils was studied by measuring nitrification in these soils under controlled laboratory conditions. Samples of surface soil collected in 1936 were mixed thoroughly, placed in series of tumblers and maintained at approximately optimum moisture and temperature in the laboratory. The samples were then removed periodically and analyzed for nitrates. Complete

results are given in Table XLI. Results for duplicate virgin and cultivated samples from each location were averaged and then plotted in graphical form (Graphs 1 to 18).

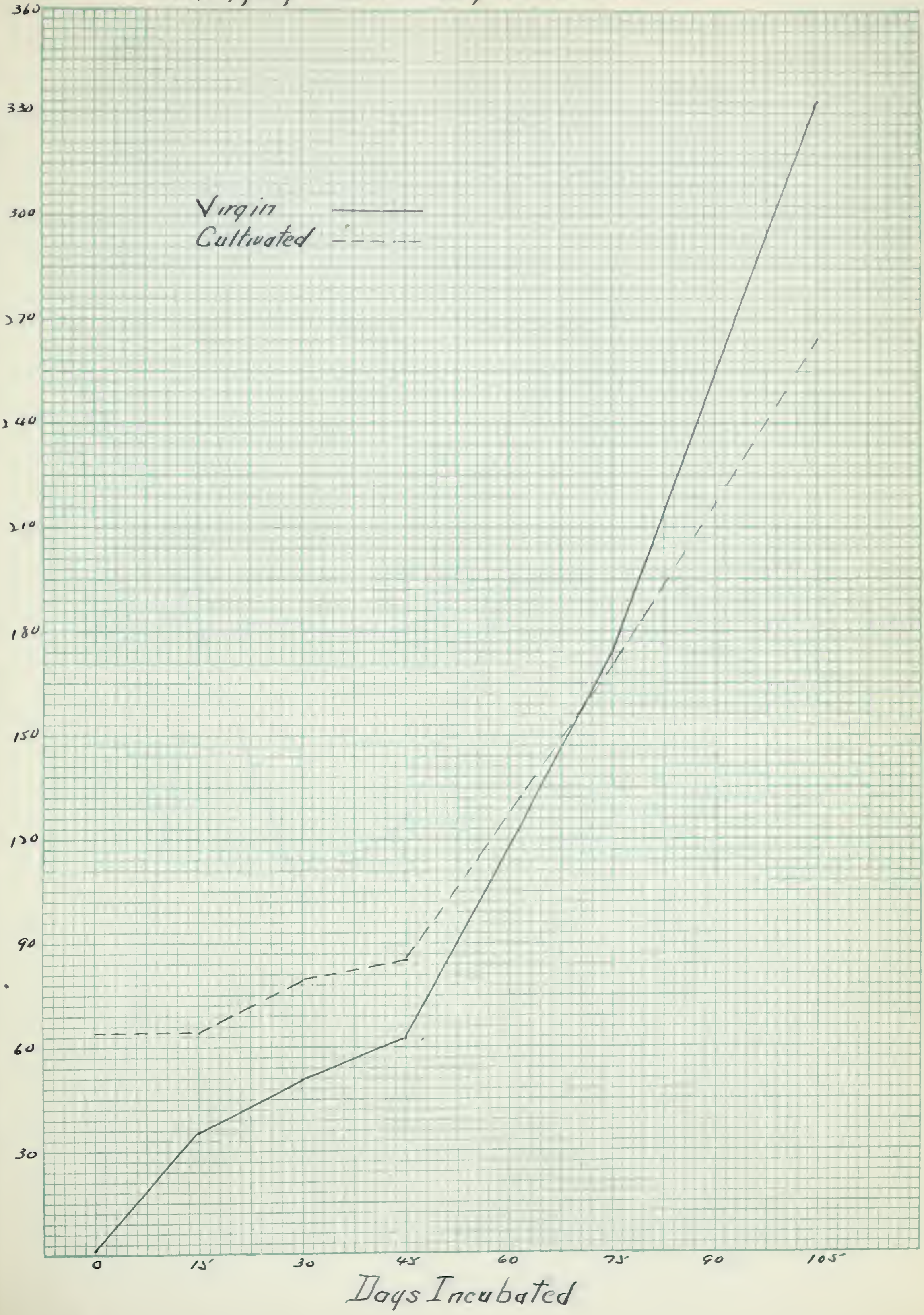
Trends in nitrate content that cultivated and virgin soils have taken, are followed more easily from the graphs.

Four out of six cultivated black soils initially have a higher nitrate content, and two start at practically the same point as the sod. After from three to three and a half months' incubation five sod samples out of six show a higher nitrate content. At only one location, Lacombe, does the cultivated soil show greater nitrifying power at all times than the sod. The general form of curve taken by the samples varies. Three follow a general upward trend, the nitrate content increasing with time. Two samples reach a fairly high level in fifteen days, then drop in the next two weeks, climbing thereafter. The sod at Pincher Creek reaches a very high level in thirty days, drops down in the next two weeks, then increases again.

The graphs show that cultivated black soils do not possess the nitrifying power the sod does after incubation for about three months or less. The nitrifying power of both virgin and cultivated black soils is very great, the sod at Edmonton reaching a nitrate content of over 300 p.p.m. in three and a half months.

Edmonton-Black-L Graph-1

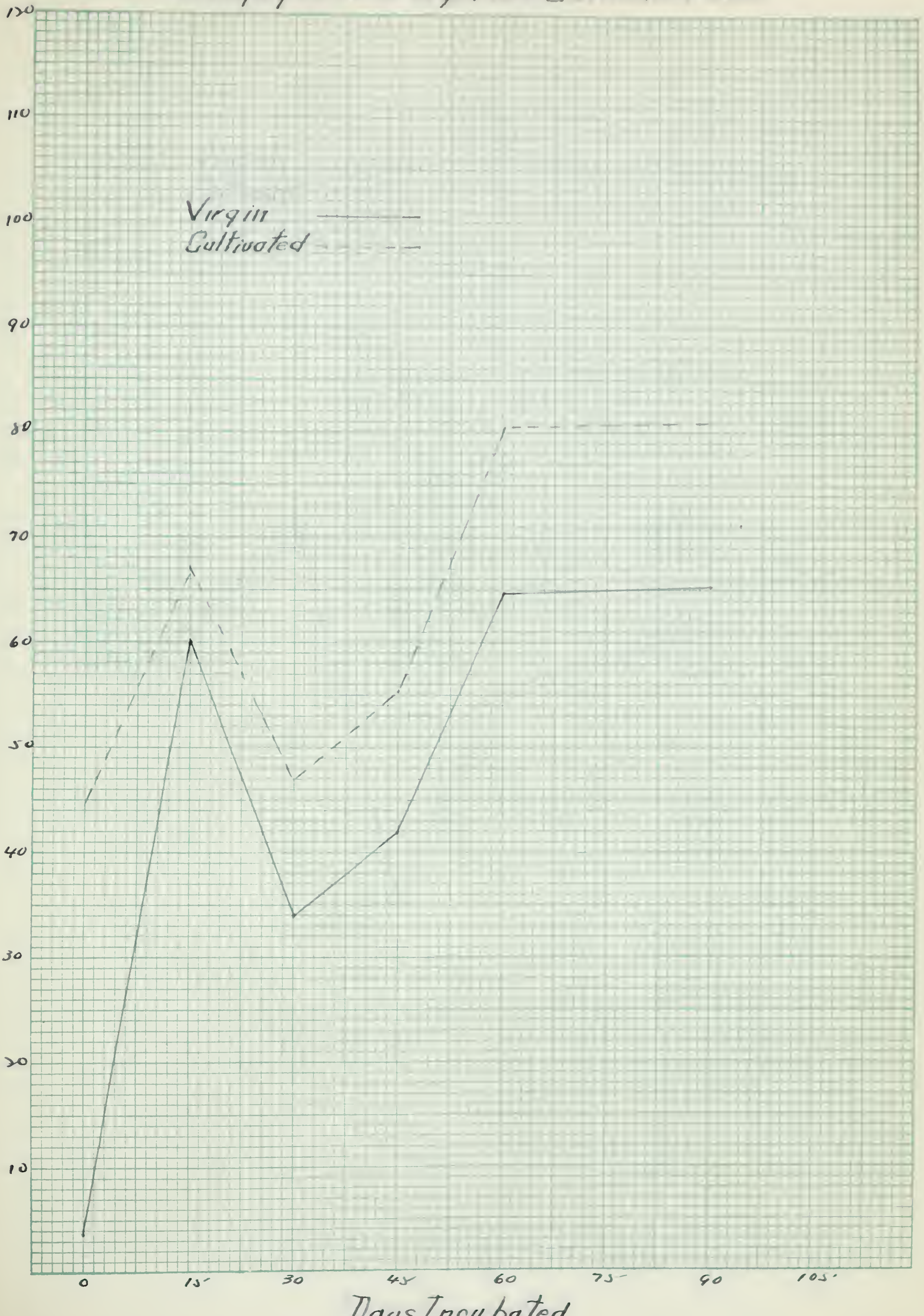
Nitrifying Power of Virgin and Cultivated Soil



Lacombe-Black-L

Graph-2

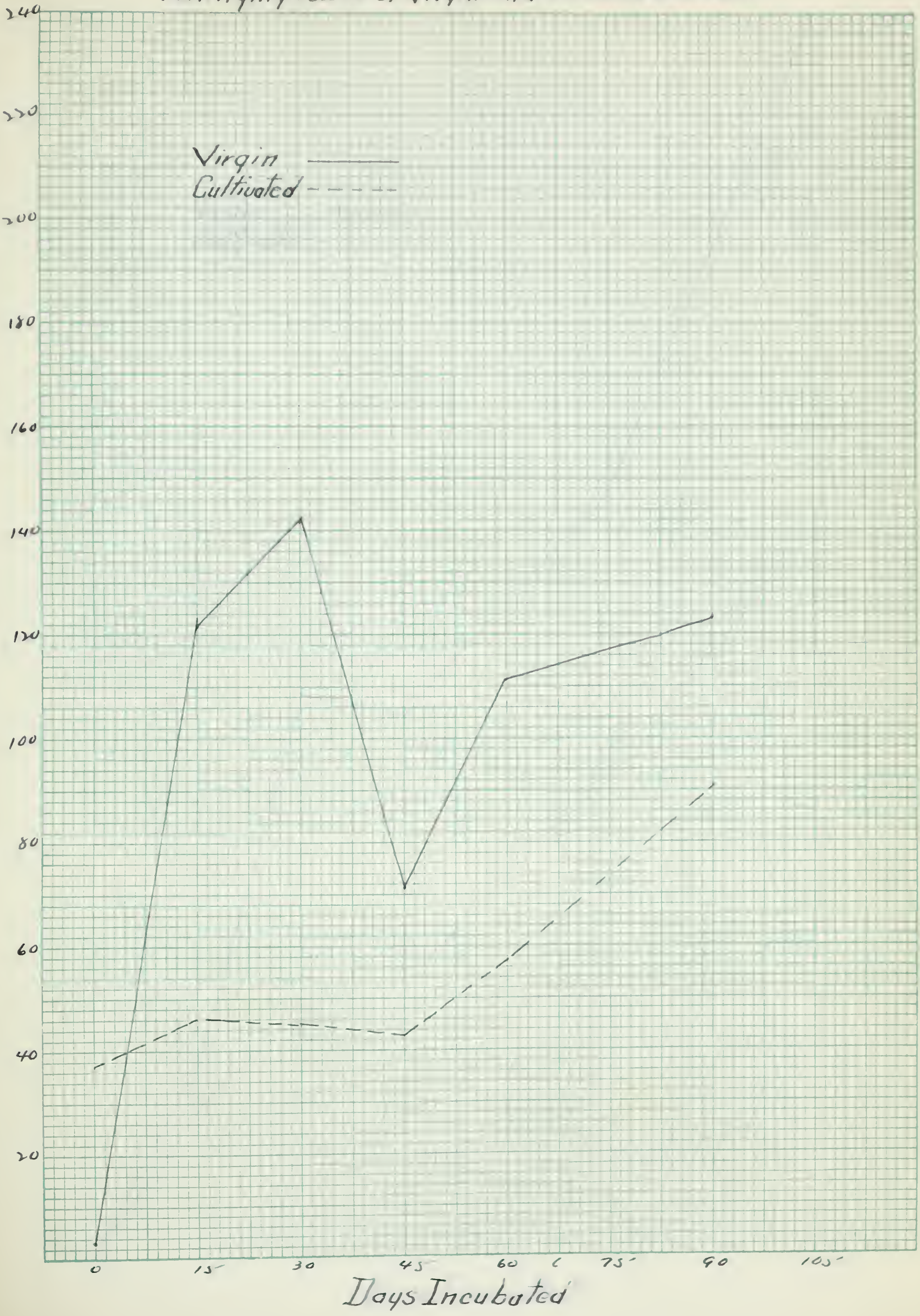
Nitrifying Power of Virgin and Cultivated Soils



Graph-3

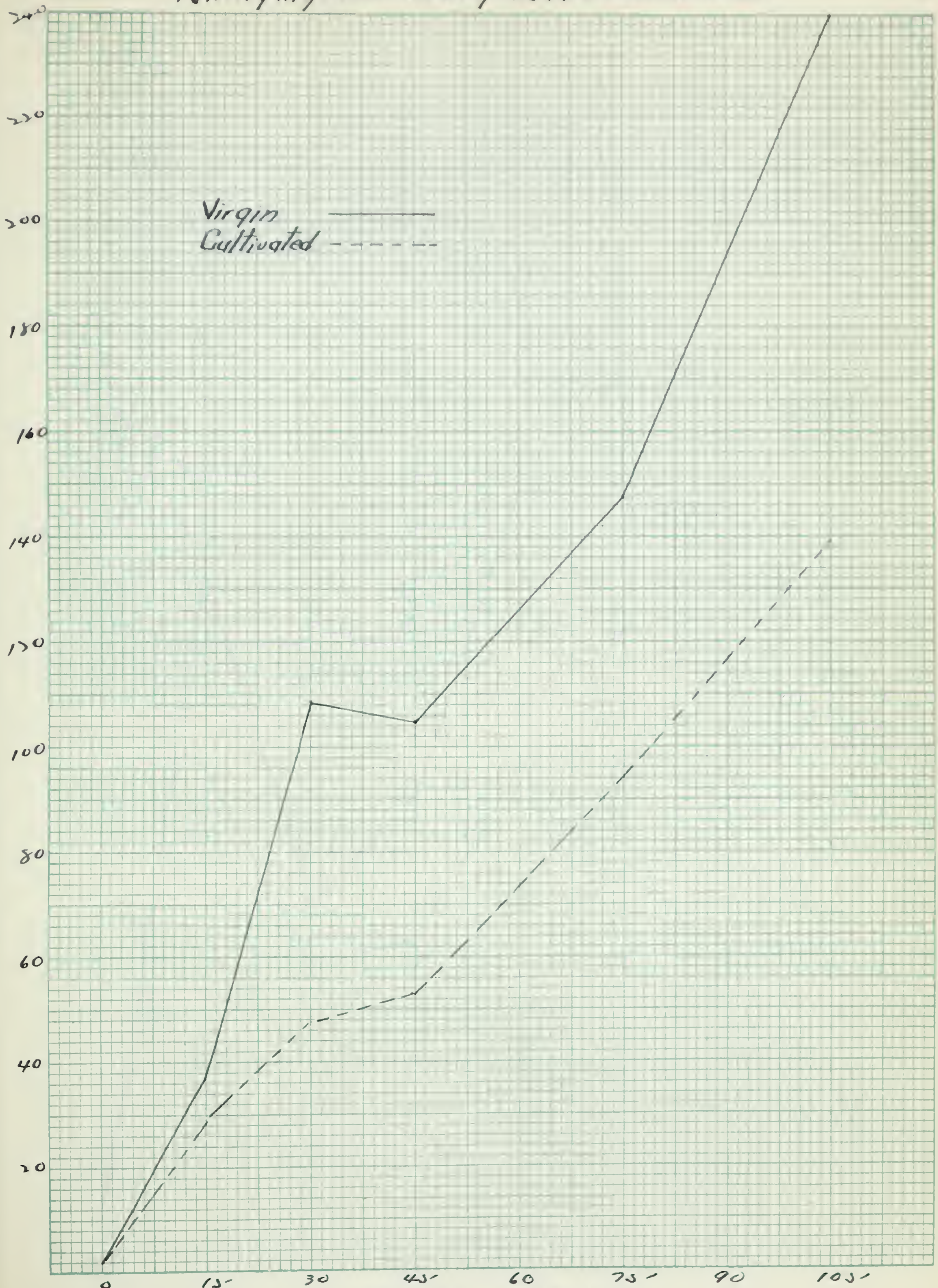
Pincher Creek - Black - SiL

Nitrifying Power of Virgin and Cultivated Soil



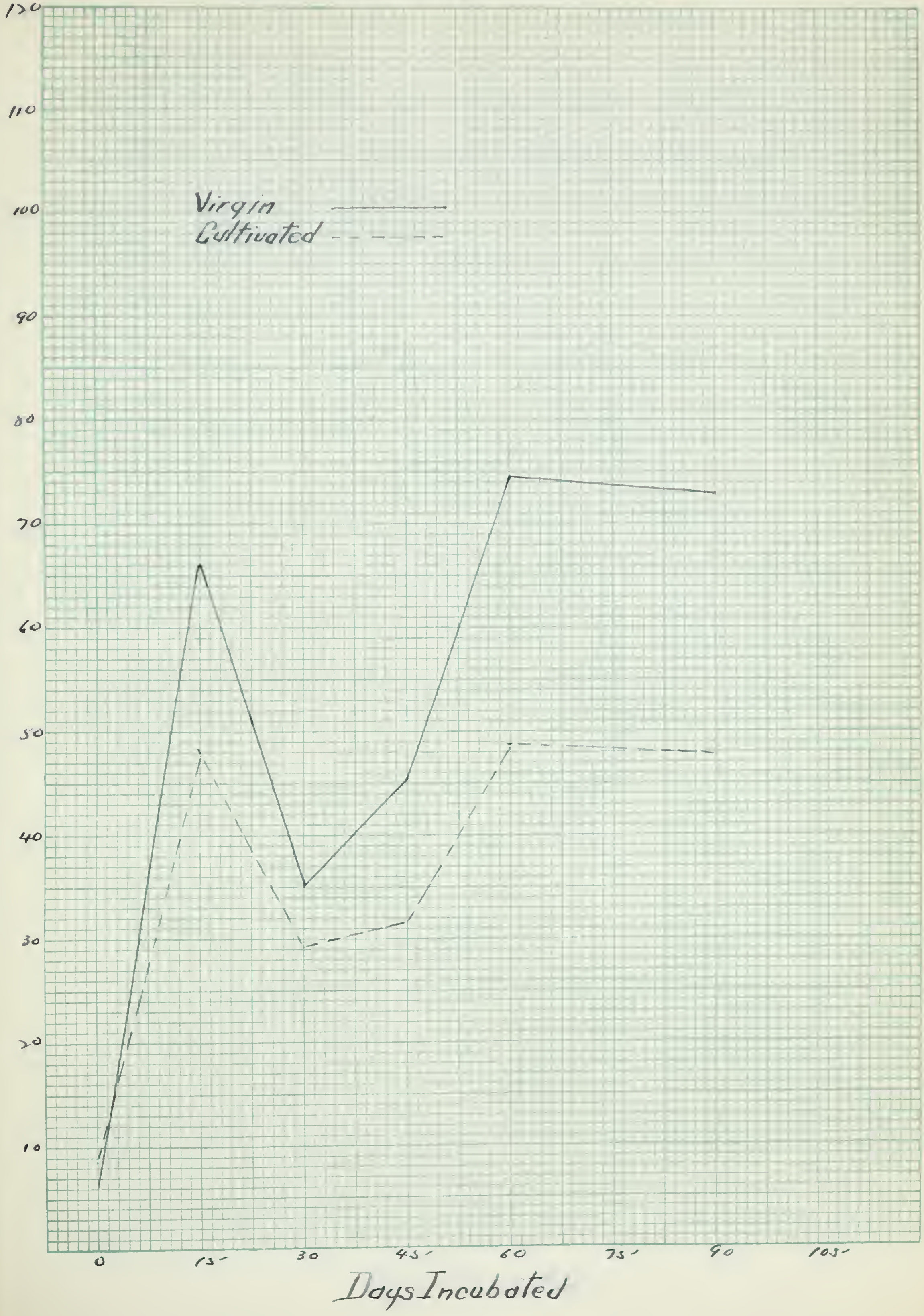
Namao-Black-L

Nitrifying Power of Virgin and Cultivated Soil



Graph-5

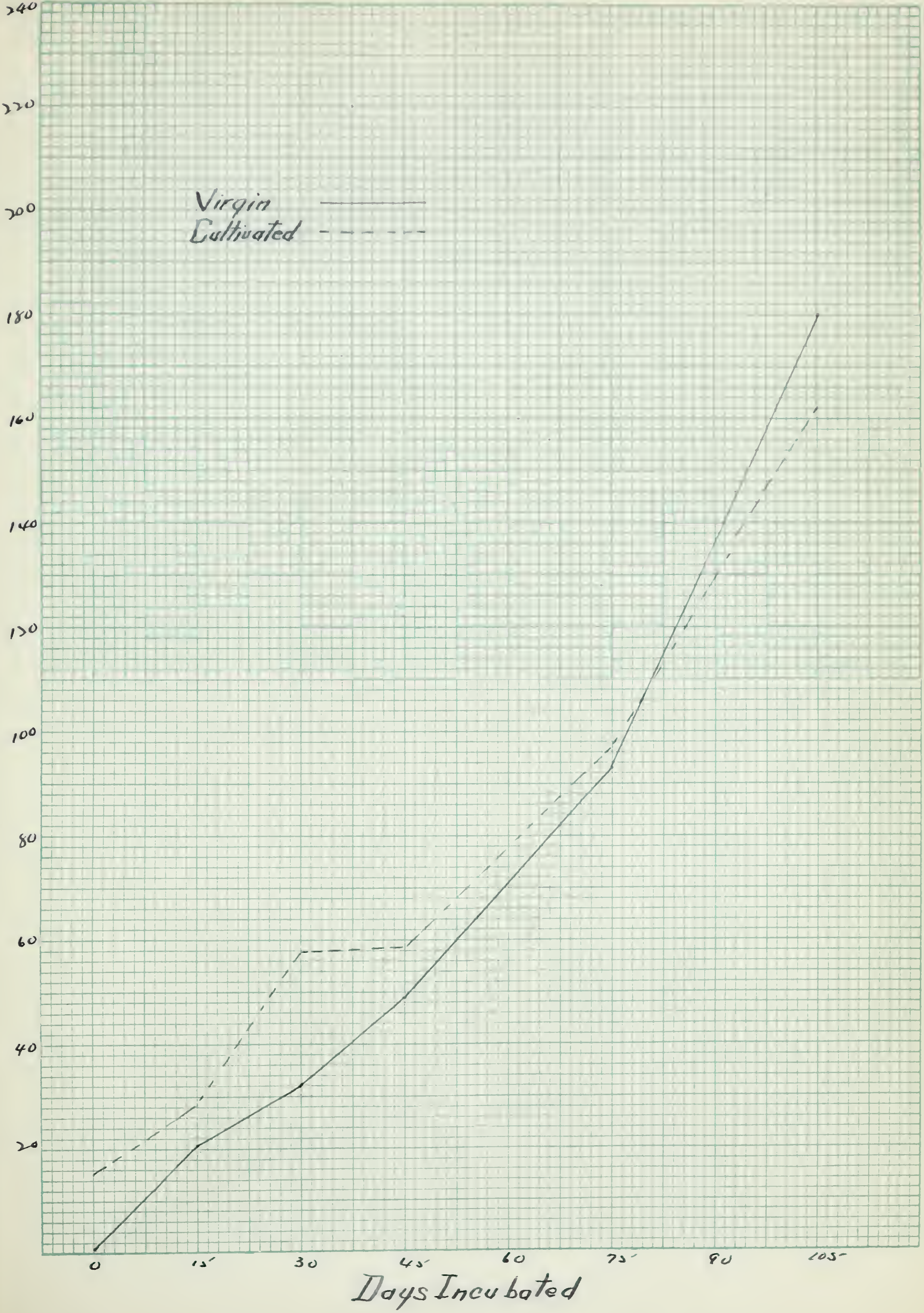
Parkland-Black-L
Nitrifying Power of Virgin and Cultivated Soil



Vegreville-Black-L

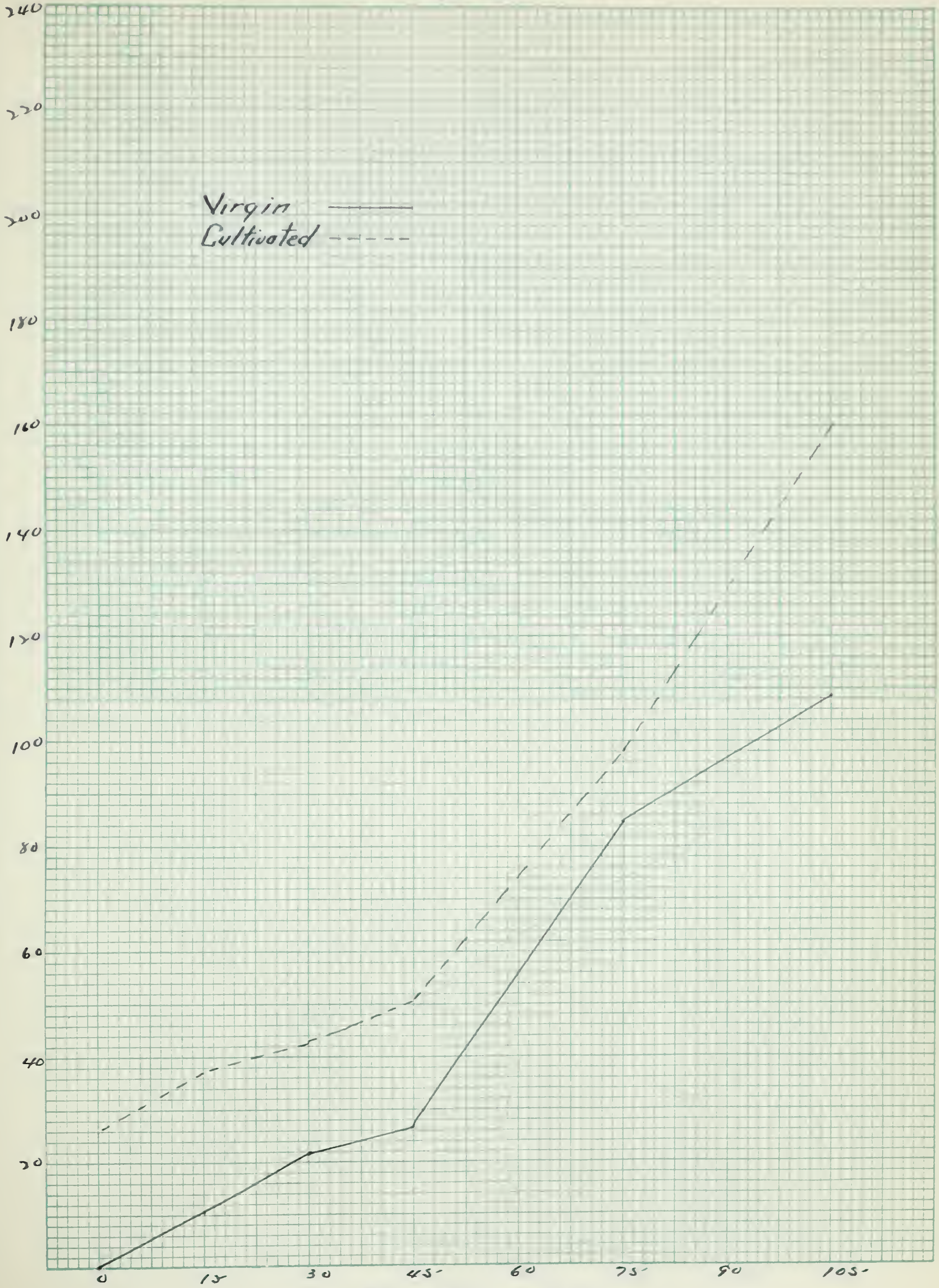
Graph-6

Nitrifying Power of Virgin and Cultivated Soil



Graph- 7

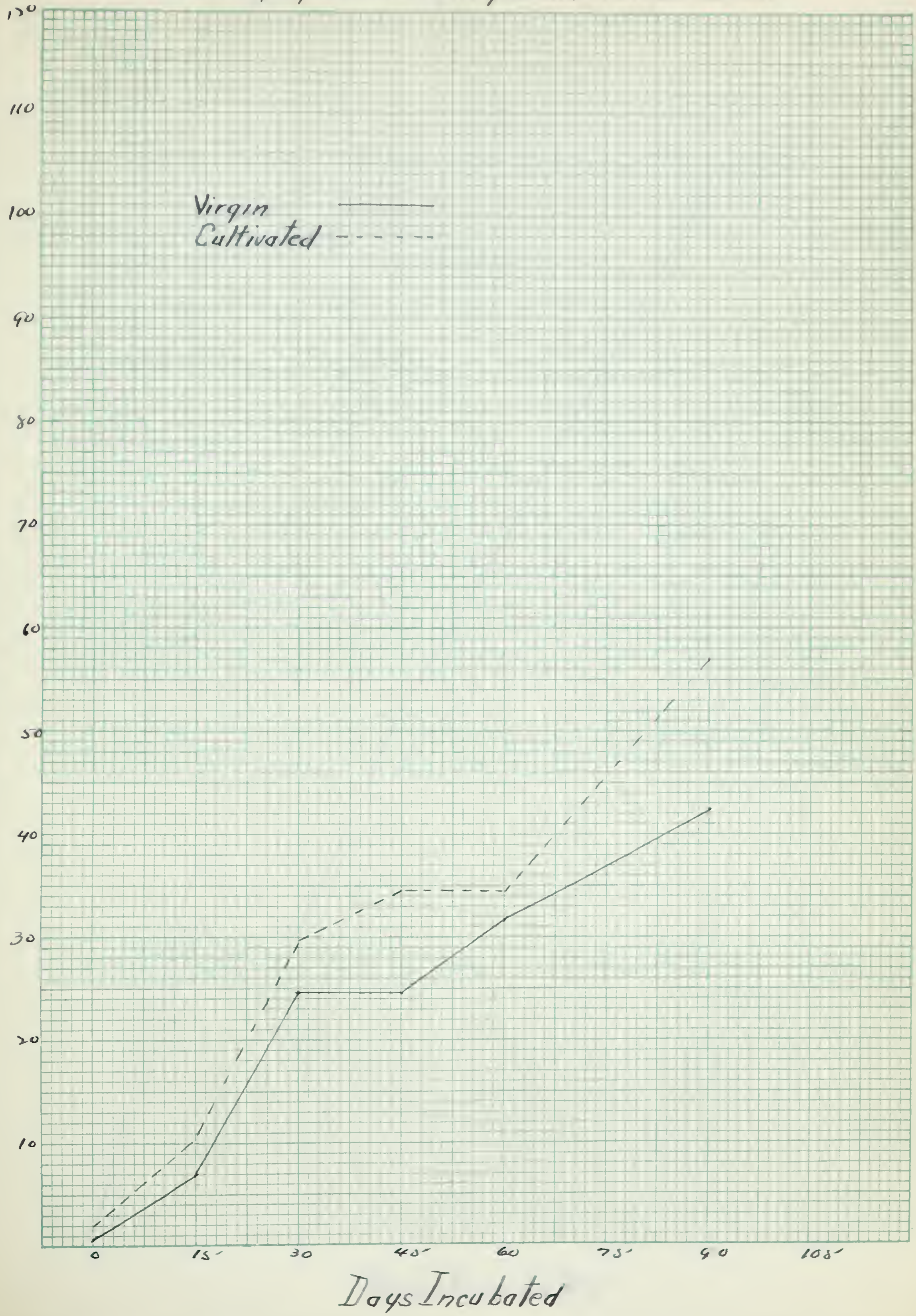
Edgerton-Dark Brown-L
Nitrifying Power of Virgin and Cultivated Soil



Days Incubated

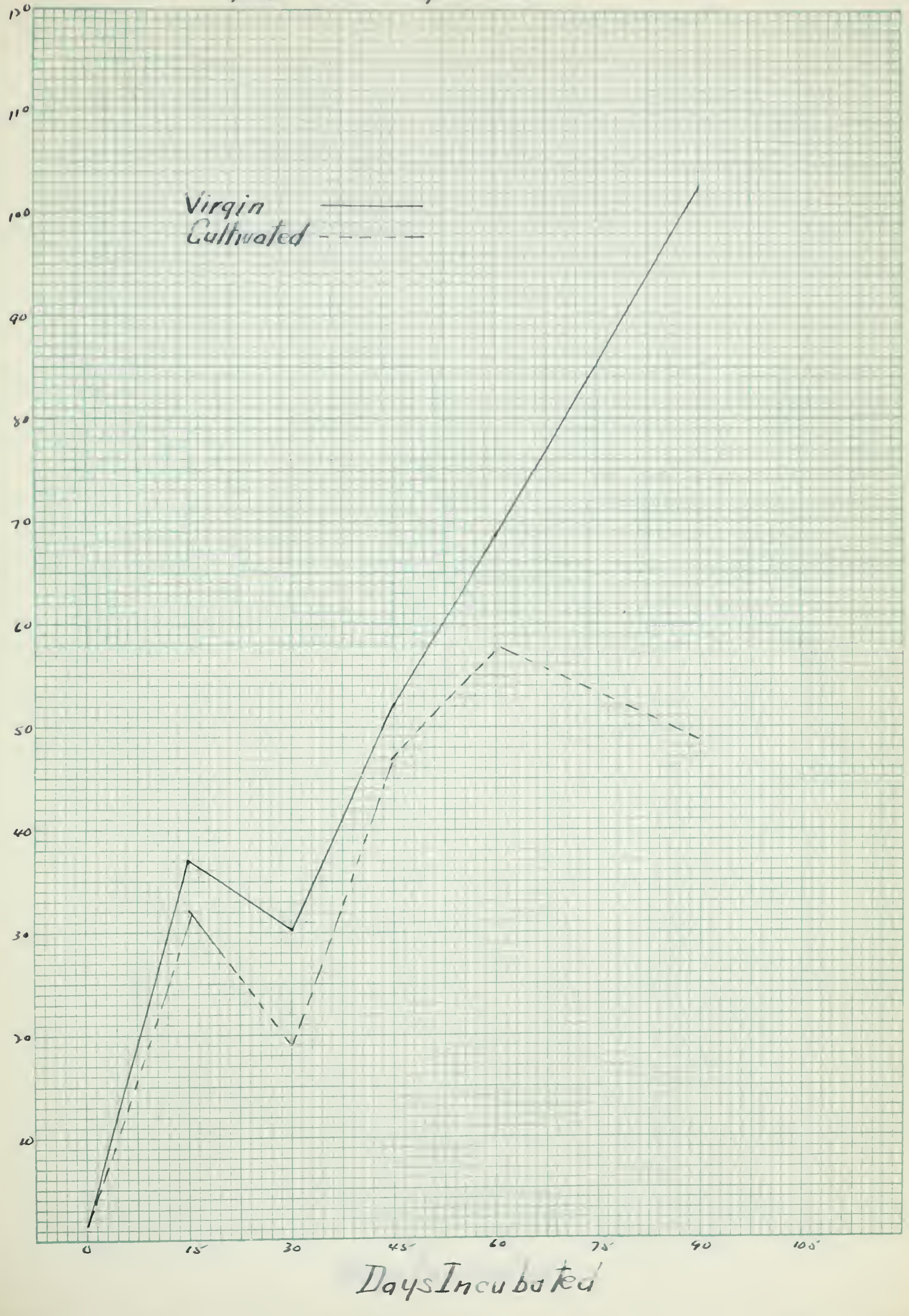
Hand Hills Dark Brown - L. Graph-8

Nitrifying Power of Virgin and Cultivated Soil

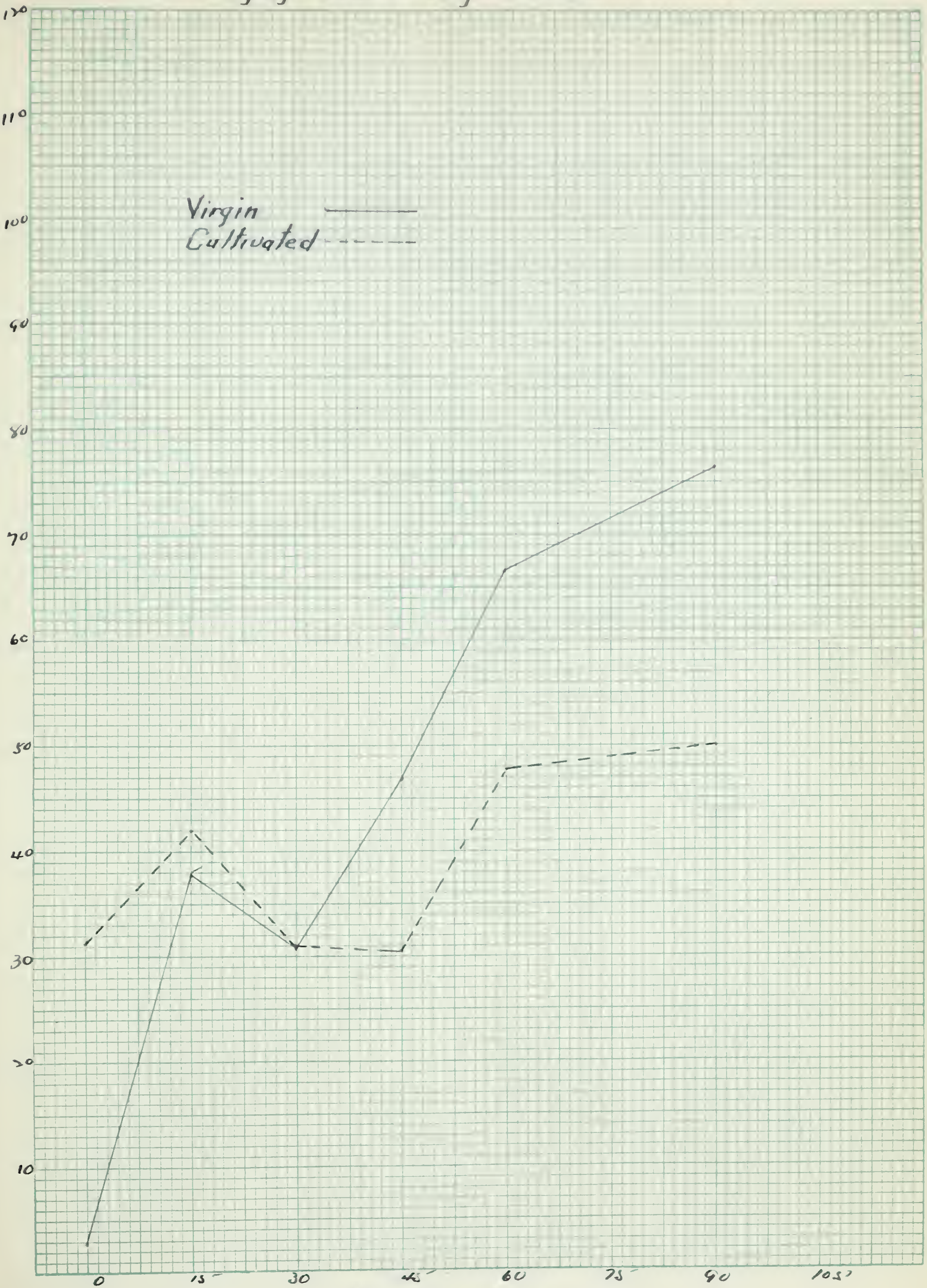


Graph-9

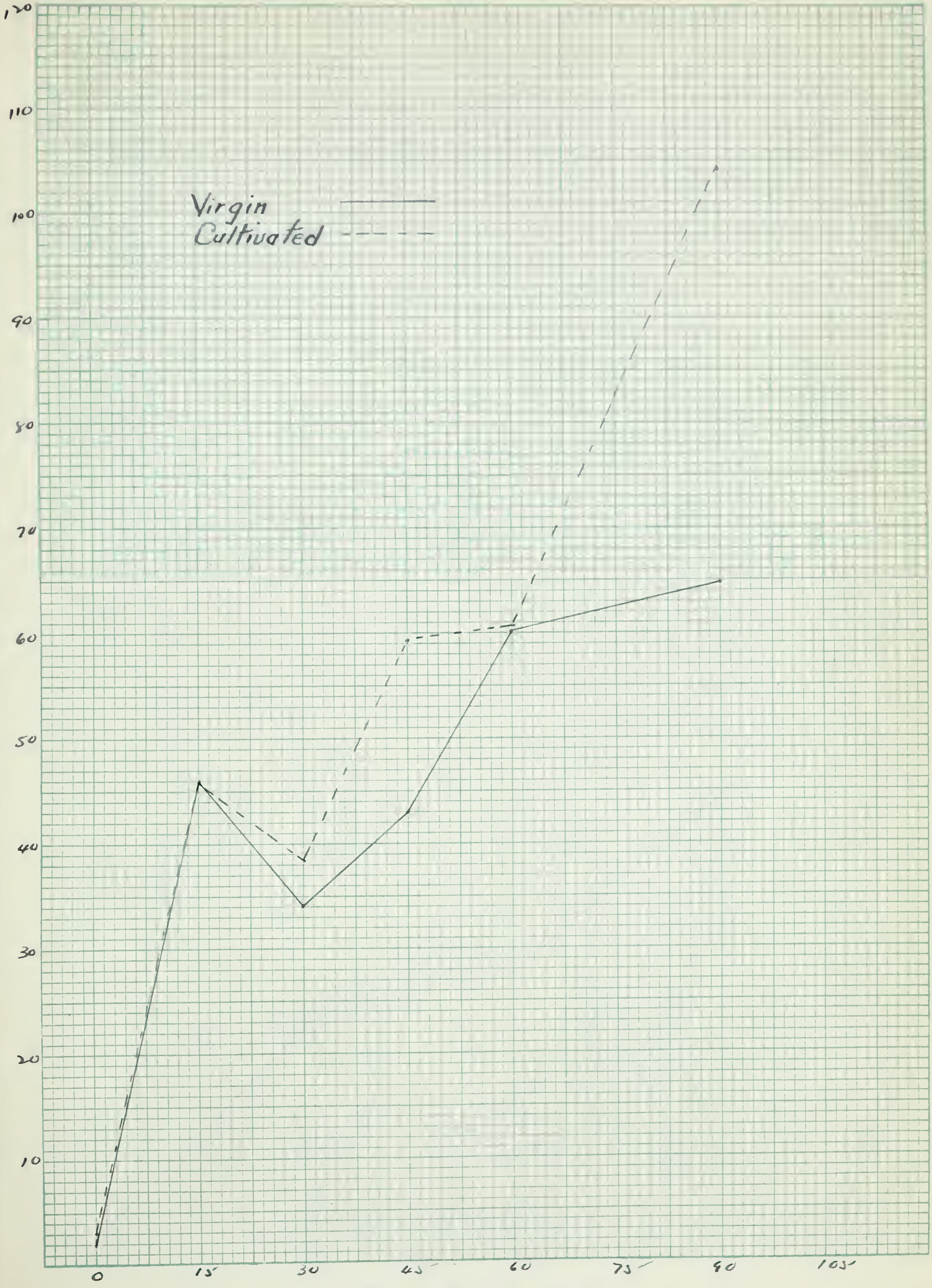
Lethbridge Dark Brown - Sil
Nitrifying Power of Virgin and Cultivated Soil



Gros Ventre Brown - L
Nitrifying Power of Virgin and Cultivated Soil



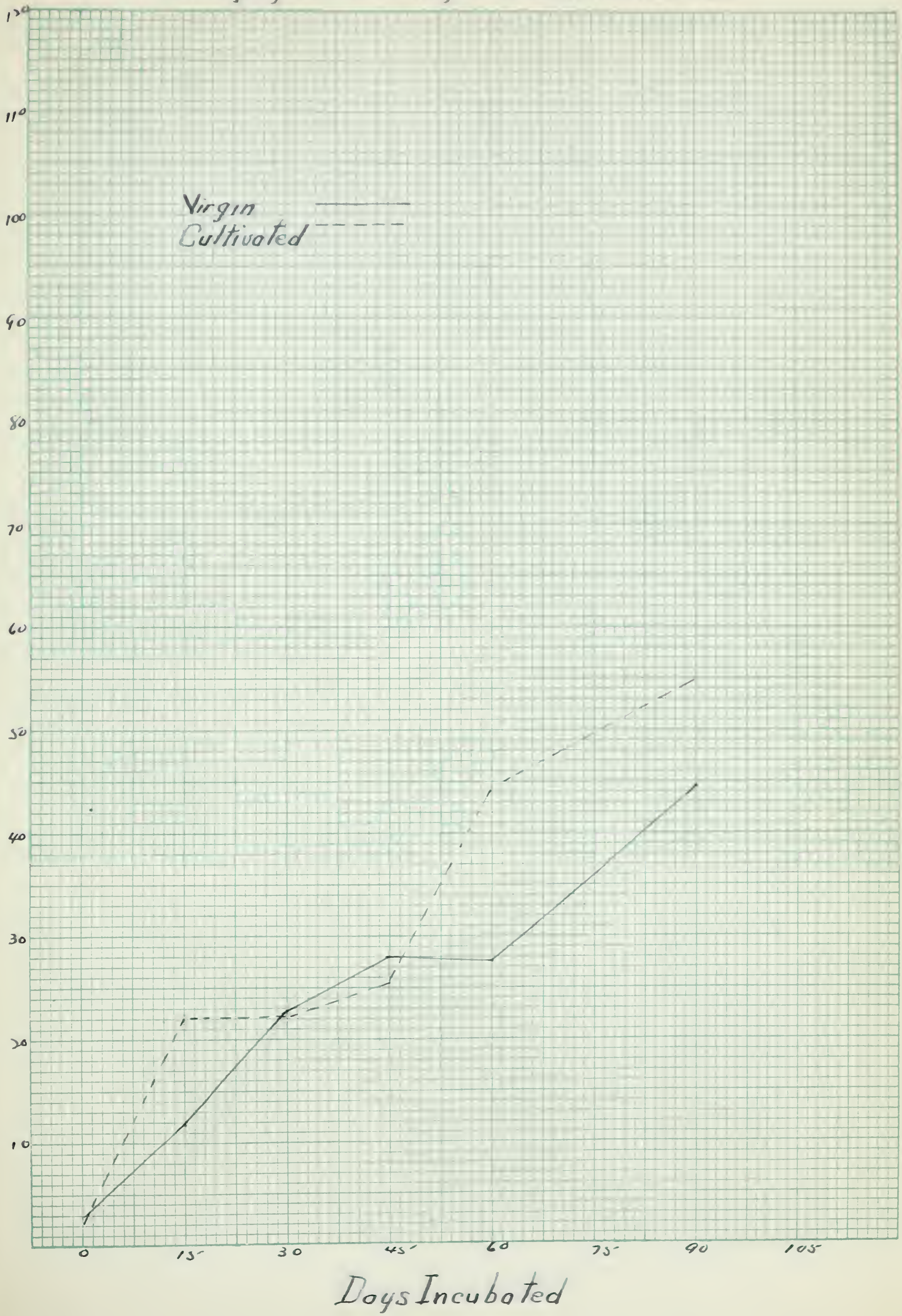
Swift Current Brown - L
Nitrifying Power of Virgin and Cultivated Soil



Cavendish Brown-FSL

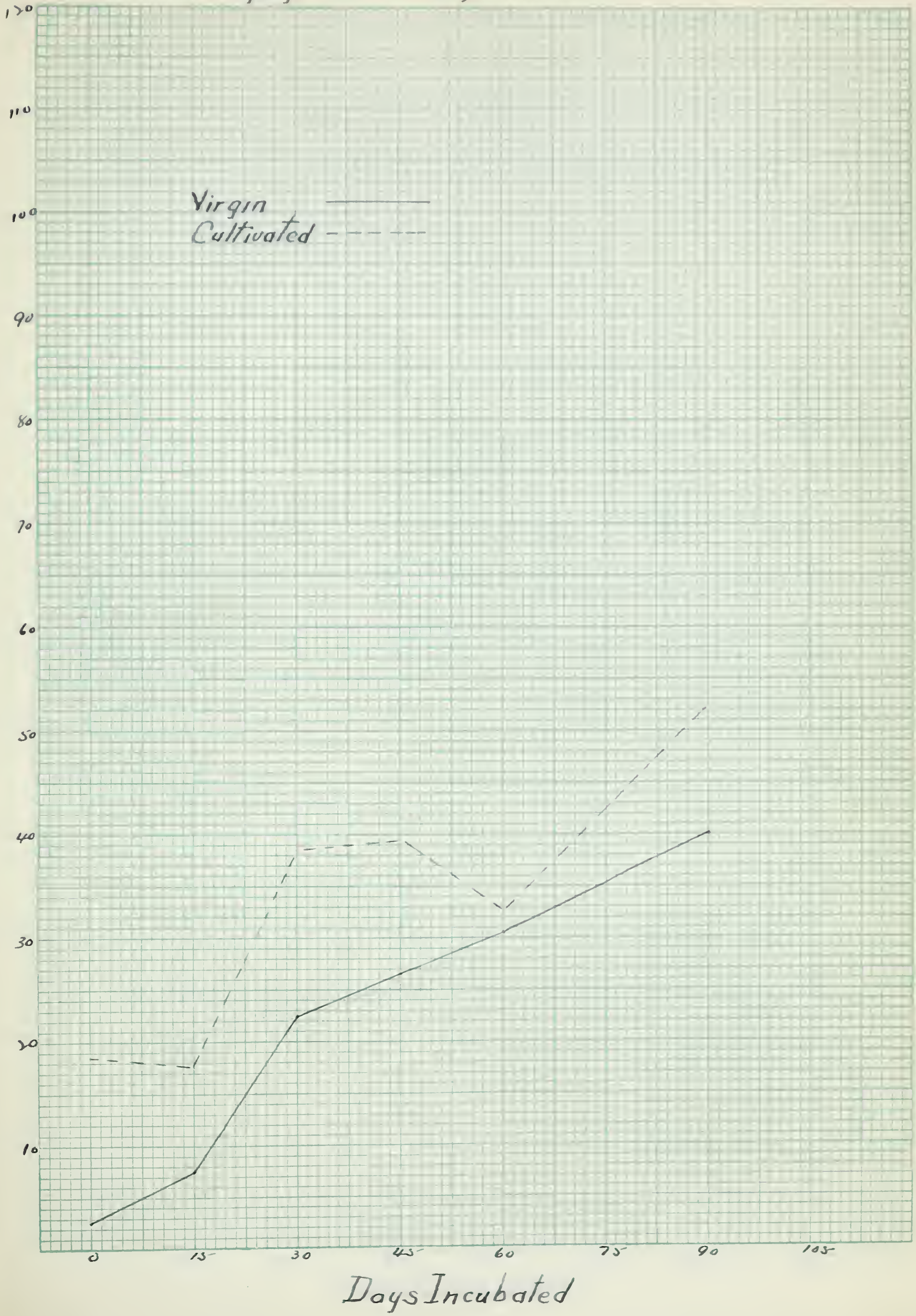
Graph-12

Nitrifying Power of Virgin and Cultivated Soil



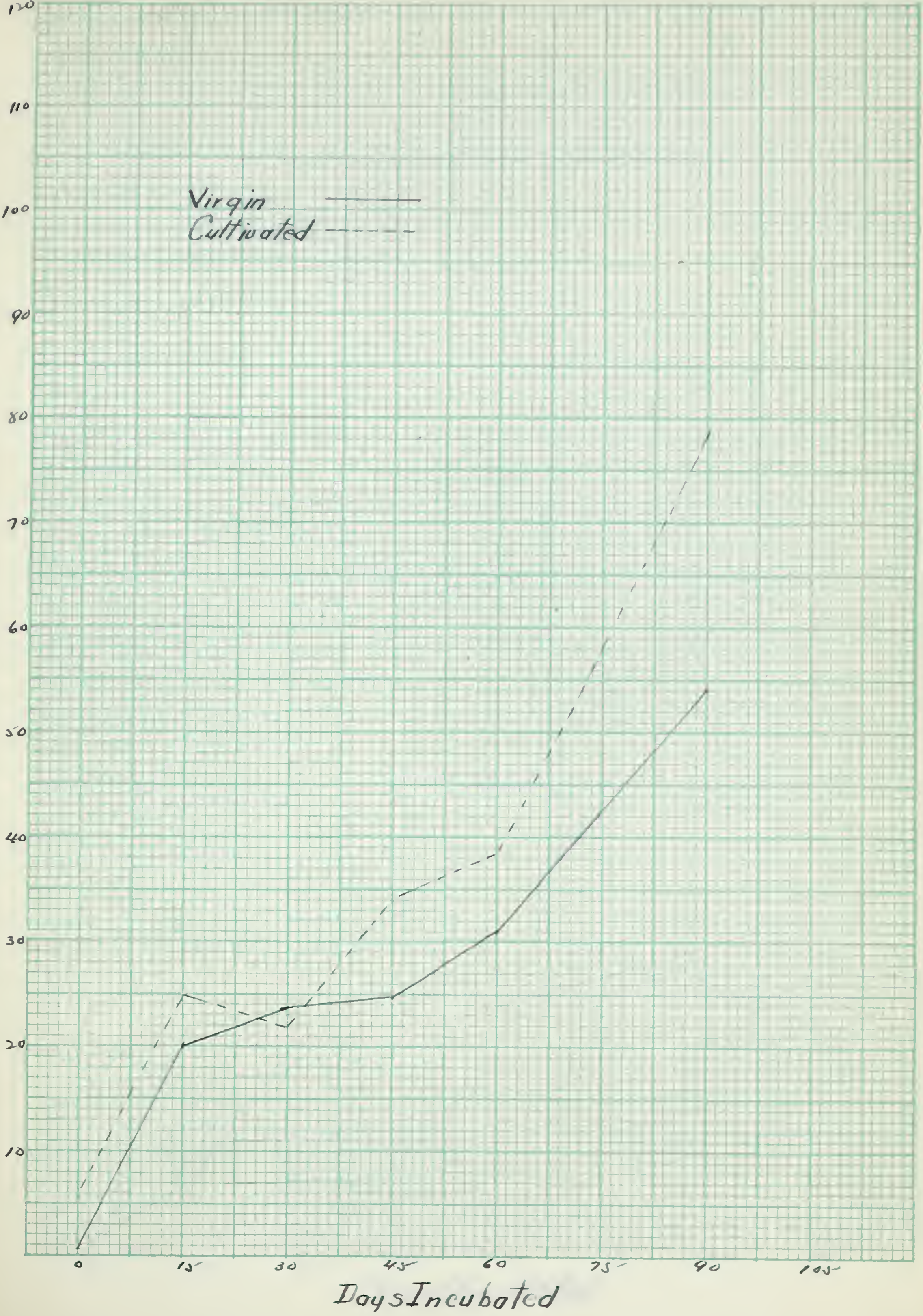
Brooks Brown-FSL Graph-13

Nitrifying Power of Virgin and Cultivated Soil



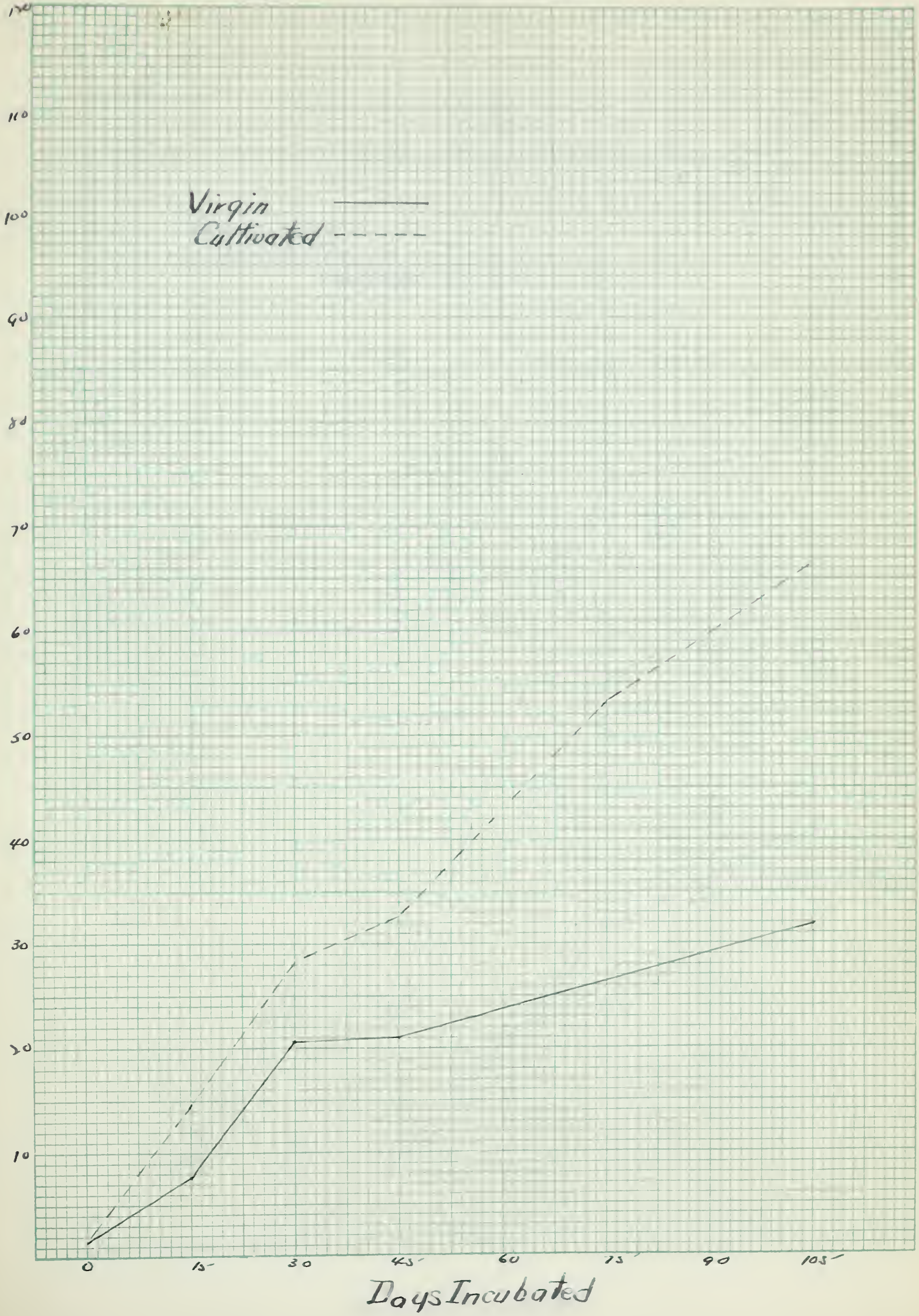
Manyberries Brown FSL Graph-14

Nitrifying Power of Virgin and Cultivated Soil



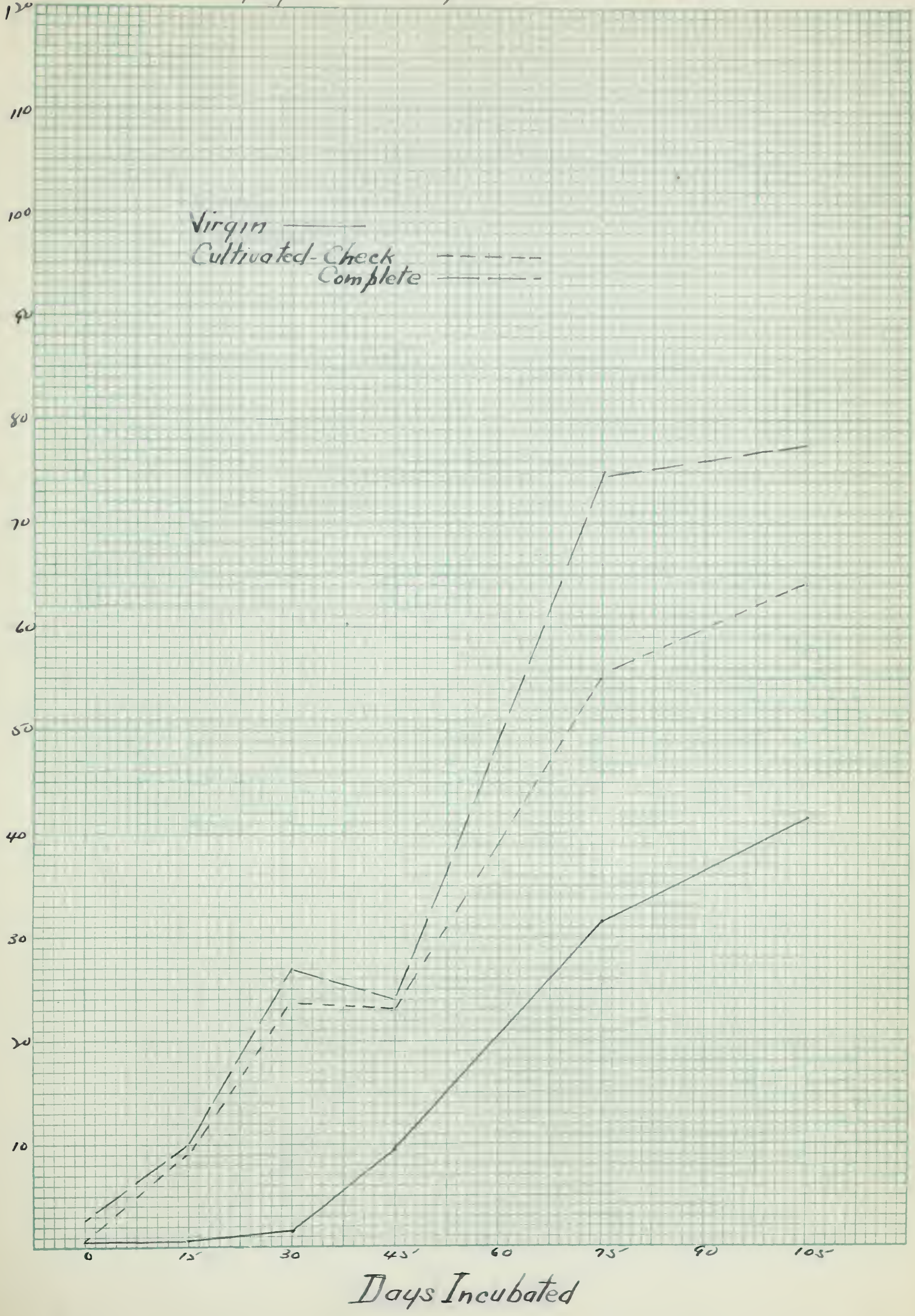
Colinton Transition Grey Wooded Si L
Nitrifying Power of Virgin and Cultivated Soil

Graph-15



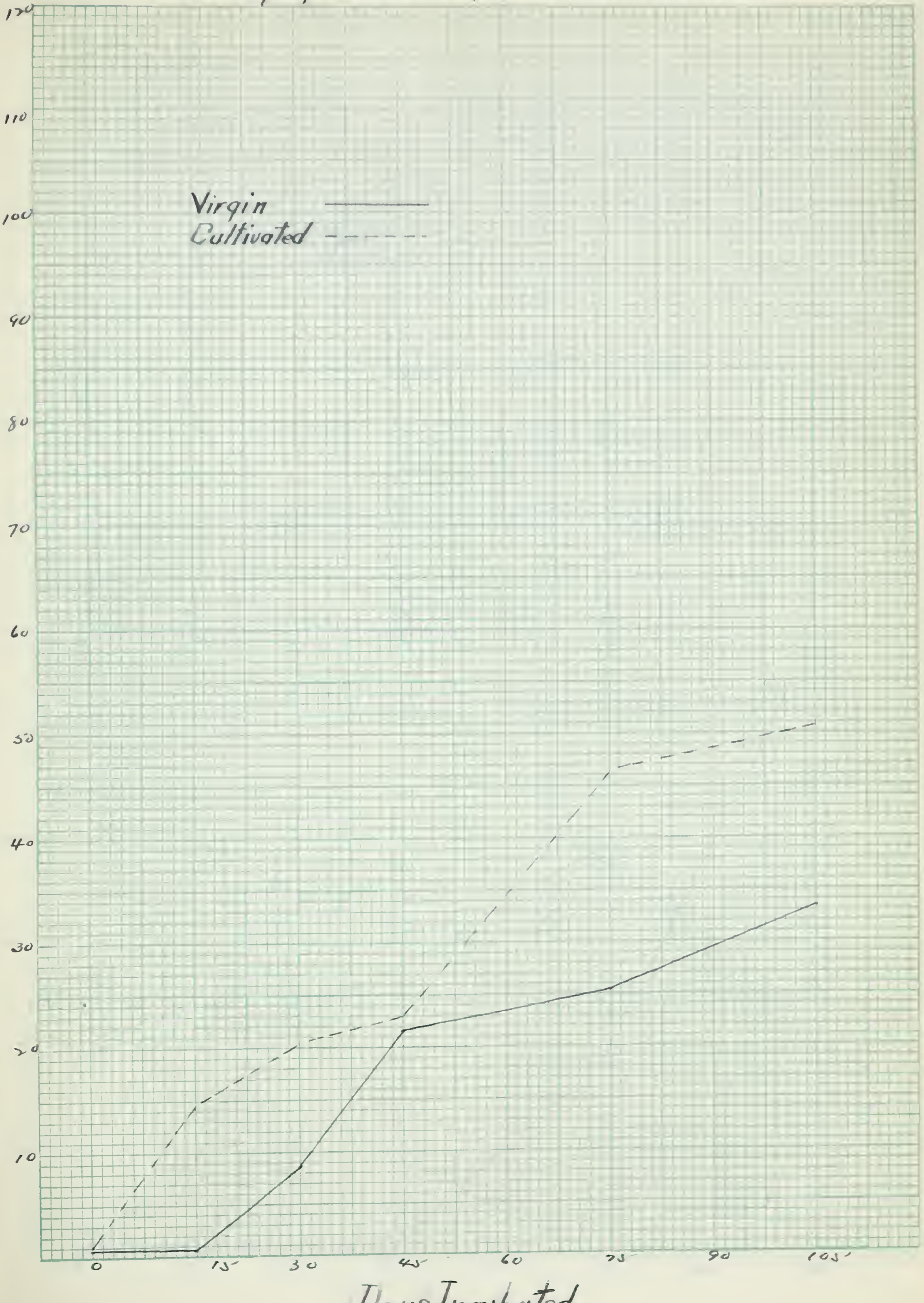
Graph-16

Breton Grey Wooded SiL
Nitrifying Power of Virgin and Cultivated Soil



Graph-17

Fallis Grey Wooded-SiL
Nitrifying Power of Virgin and Cultivated Soil



Graph-18

Mackay-Grey Wooded-SiL
Nitrifying Power of Virgin and Cultivated Soil

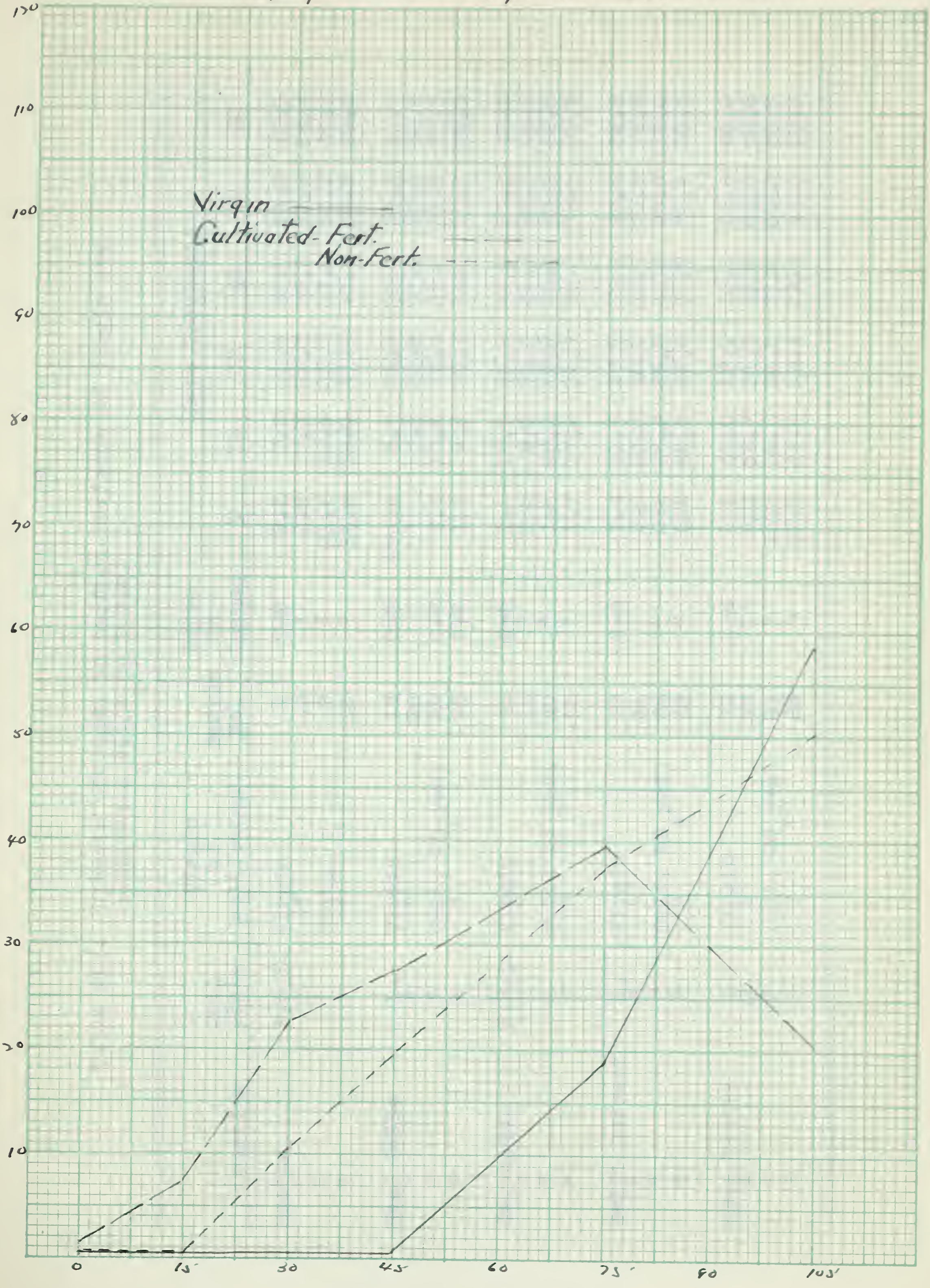


Table XLI. Nitrate nitrogen in surface horizons of virgin and cultivated soils in P.P.M.

Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Days Incubated					
					0	15	30	45	60	90
Brooks	F.S.L.	Virgin	1	0-9	2.5	7.8	22.2	22.7	33.3	43.5
"	"	"	5	"	2.0	7.3	22.7	30.3	27.8	36.4
"	"	Cult.	9	"	21.6	16.6	35.7	37.0	33.3	46.5
"	"	"	13	"	15.0	19.0	41.7	41.6	32.3	58.8
Hand Hills	L.	Virgin	17	0-8	Trace	6.6	25.6	25.0	30.3	41.7
"	"	"	20	"	"	7.5	23.8	23.9	33.3	43.5
"	"	Cult. 20 yrs.	23	0-6	2.4	10.6	29.4	34.0	31.3	51.3
"	"	" "	26	0-8	1.4	9.8	29.4	34.5	37.0	62.5
Cavendish	F.S.L.	Virgin	41	0-5	1.3	13.8	22.2	33.3	27.0	43.5
"	"	"	45	"	2.3	9.6	23.3	22.7	28.6	45.5
"	"	Cult. 23 yrs.	49	"	1.8	26.3	22.2	25.0	50.0	58.8
"	"	"	53	"	1.7	17.5	22.7	26.7	38.5	51.3
Swift Current	L.	Virgin	57	0-6	1.4	41.7	27.8	33.3	43.5	52.6
"	"	"	61	"	2.8	50.0	40.0	52.7	76.9	76.9
"	"	Cult. 20 yrs.	65	"	2.2	45.5	33.3	41.8	50.0	125.0
"	"	" "	69	"	3.5	45.5	43.5	77.0	71.4	83.3
Gros Ventre	L.	Virgin	73	0-6	3.5	40.0	29.9	50.0	66.6	90.9
"	"	"	77	"	2.2	35.7	31.3	43.5	66.6	62.5
"	"	Cult. 20 yrs.	81	"	35.2	50.0	32.3	31.2	50.0	50.0
"	"	" "	85	"	27.2	34.5	29.4	29.4	45.5	50.0

Table XLI (Continued)

Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Days Incubated					
					0	15	30	45	60	90
Manyberries	L.	Virgin	89	0-6	Trace	19.2	19.2	23.9	28.6	52.6
"	"	"	93	"	"	20.4	28.6	25.7	33.3	55.5
"	"	Cult. 23 yrs.	97	"	2.7	23.8	18.5	33.3	31.3	74.1
"	"	" "	101	"	8.8	28.6	25.0	34.6	45.5	83.3
Lethbridge	Si.L.	Virgin	105	0-5	1.6	27.0	35.1	62.5	66.6	133.3
"	"	"	109	"	1.6	27.0	25.0	41.7	60.6	71.4
"	"	Cult. Rot. U	113	"	1.7	27.0	20.0	50.0	62.5	42.6
"	"	" "	117	"	1.7	37.0	19.6	41.7	52.6	54.1
Pincher Creek	Si.L.	Virgin	121	0-7	3.0	125.0	181.8	--	190.0	--
"	"	"	125	"	2.0	118.0	100.0	71.5	52.6	133.3
"	"	Cult. 27 yrs.	129	"	34.0	42.0	45.4	50.0	83.3	86.9
"	"	" "	133	"	40.0	50.0	43.5	34.6	71.4	95.2
Parkland	L.	Virgin	137	0-6	5.4	63.0	34.5	43.5	76.9	76.9
"	"	"	141	"	7.0	69.0	35.7	47.6	71.4	68.9
"	"	Cult. 27 yrs.	145	"	6.6	36.0	26.0	26.5	45.5	51.9
"	"	" "	149	"	10.0	59.0	32.3	37.0	51.3	43.5
Lacombe	L.	Virgin	153	0-6	4.4	63.0	34.5	38.5	62.5	76.9
"	"	"	158	"	3.0	56.0	33.3	45.5	66.6	53.3
"	"	(Cult. 25 yrs.	163	"	55.6	80.0	55.5	66.8	83.3	95.2
"	"	(Rot. C	167	"	33.6	53.0	47.6	43.5	76.9	66.6

Table XLI (Continued)

Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Days Incubated					
					0	15	30	45	75	105
Breton	Si.L.	Virgin	173	0-7	Trace	Trace	Trace	Trace	6.0	17.4
"	"	"	178	"	"	"	3.0	19.2	57.2	65.6
"	"	(Cult. Ser.C 1	181	"	"	10.0	22.7	22.7	50.0	57.0
"	"	(Check	185	"	"	8.3	25.0	23.8	60.6	71.4
"	"	Cult. Ser.C 3)	189	"	"	6.3	20.8	18.2	77.0	68.0
"	"	N.P.K.S.)	193	"	5.0	13.9	33.3	29.4	71.4	87.0
Fallis	Si.L.	Virgin	199	0-7	Trace	Trace	11.4	20.8	40.0	33.6
"	"	"	204	"	"	"	5.7	21.7	10.4	33.4
"	"	Cult. 24 yrs.	206	"	"	16.1	22.7	18.2	--	51.3
"	"	" "	210	"	"	12.5	18.5	27.8	46.5	50.0
MacKay	Si.L.	Virgin	216	0-7	Trace	Trace	Trace	Trace	21.3	64.4
"	"	"	222	"	"	"	"	"	18.3	52.6
"	"	(Cult. 5 yrs.	226	"	1.6	9.6	25.0	27.0	28.6	20.4
"	"	(Fertilized	229	"	1.5	5.2	20.8	27.8	50.0	--
"	"	Cult. 3 yrs.)	232	"	Trace	Trace	7.4	18.5	35.1	45.4
"	"	Unfertilized)	234	"	"	"	14.3	20.0	39.2	55.5
Colinton	Si.L.	Virgin	238	0-8	Trace	Trace	14.3	20.8	--	48.7
"	"	"	243	"	2.5	14.7	26.3	20.8	--	15.2
"	"	Cult. 20 yrs.	246	0-6	Trace	15.6	28.9	38.5	52.6	66.7
"	"	" "	251	"	2.6	13.9	27.4	27.0	54.0	66.7

Table XLI (Continued)

Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Days Incubated 0	15	30	45	75	105
Namao	L.	Virgin	256	0-9	1.9	45.5	133.3	125.0	174.0	258.0
"	"	"	261	"	2.0	27.8	83.3	83.3	121.0	222.0
"	"	Cult. 30 yrs.	266	"	2.2	30.3	--	52.6	91.0	119.0
"	"	" "	271	"	1.9	27.8	47.6	52.6	83.5	160.0
Vegreville	L.	Virgin	276	0-8	Trace	23.8	34.5	50.0	91.0	200.0
"	"	"	280	"	"	20.8	29.4	47.6	95.0	160.0
"	"	Cult. 30 yrs.	284	0-6	16.6	29.4	71.4	66.7	89.0	174.0
"	"	" "	288	"	14.7	27.8	44.4	50.0	105.0	151.0
Edgerton	L.	Virgin	292	0-8	Trace	11.6	20.0	20.0	75.5	99.0
"	"	"	296	"	"	9.4	23.8	33.3	93.0	138.0
"	"	Cult. 26 yrs.	299	"	20.8	30.3	35.7	43.4	93.0	138.0
"	"	" "	303	"	31.3	43.4	50.0	57.1	103.0	182.0
Edmonton	L.	Virgin	307	0-7	Trace	33.3	52.6	66.7	143.0	276.0
"	"	"	312	"	"	38.5	50.0	60.6	205.0	390.0
"	"	Cult. 20 yrs.	317	"	66.6	62.5	76.9	86.9	154.0	259.0
"	"	" "	321	"	62.5	66.6	83.3	105.3	190.0	276.0

The relative nitrifying power of cultivated and virgin samples from the dark brown and brown soil zones is presented in graphs 7 to 14 inclusive. Five out of eight cultivated fields show more nitrates early in the incubation period, and three cultivated fields start even with the corresponding sod. Curves for virgin and cultivated samples from the same location are usually much alike. The nitrate content of samples from five locations increases gradually with the length of time incubated. The samples from Lethbridge, Gros Ventre, and Swift Current, show a drop in nitrates in the fifteen to thirty day period, gradually increasing from then on.

At the end of the incubation period only two sod samples, those from Lethbridge and Gros Ventre, show a greater nitrate content than the cultivated fields from the same localities. That is, six out of eight cultivated dark brown and brown soils possess greater nitrifying power than corresponding sod after three months' incubation.

Graph 15 contains the curves for the nitrate content found in the sod and cultivated soils collected at Colinton, in the gray transition soil zone. The samples start with the same amount of nitrate, which increases gradually with time. However, after three and a half months' incubation the cultivated soil contains twice as much nitrate as the virgin sod.

In Graphs 16, 17 and 18 may be found the curves for the nitrifying power of virgin and cultivated soils from the gray wooded soil zone.

Only traces of nitrate could be found in the soils to start with. The nitrate content of the cultivated soils then rises fairly quickly. The sod lags behind and shows very little nitrate at Breton and Fallis till four weeks later, and it was ten weeks till appreciable amounts were detected in the MacKay sample.

After 105 days incubation the cultivated soils at Breton and Fallis were higher in nitrate content, at MacKay the sod was generally lowest, but was highest at the last, with the non fertilized field just slightly below it. The fertilized sample at MacKay had fallen off in nitrate content from 40 to 20 p.p.m. in the last month.

The complete fertilizer on Plot C 3 at Breton apparently caused an increased production of nitrate nitrogen over that found in Plot C 1, unfertilized.

Summary of nitrification studies

After three months' incubation sod soils from the black belt generally possess greater nitrifying power than do the cultivated soils.

After three months' incubation cultivated soils from the dark brown, brown, transition gray, and gray belts

generally contained more nitrates than the sod.

Nitrates were very slow in accumulating in the gray wooded sod samples.

Potassium Results

A determination was made of the total potassium in the surface of virgin and cultivated soils from six widely scattered localities, two in the black zone, two in the brown zone and one each in the dark brown and gray wooded soil zones.

An inspection of Table XLII shows that Alberta soils are quite high in potassium content, the variation in six samples being from about 1.40 to 1.50 per cent. This amounts to about 25,000 pounds of potassium per acre, six inches.

Decreases of potassium were found at three locations. Increases were found at four. Losses occurred at Edmonton, Parkland and Cavendish and were 105, 270 and 675 pounds per acre respectively. Gains were of a higher order, 750 pounds at Lethbridge, 1,080 pounds at Gros Ventre, where there was incidentally a large loss of nitrogen and organic matter, 735 pounds in Plot C 1 at Breton and 1,470 pounds in Plot C 3 at Breton. Though the average total increases exceed the average total losses, it cannot be said that there is a general increase in cultivated soils. The number of increases and decreases are about the same, and the data reported are for only six samples. These differences must be attributed mainly to soil variability.

Table XLII. Total potassium and loss or gain of potassium as per cent. and pounds per acre in some virgin and cultivated black, dark brown, brown and gray wooded soils

Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Total K				
					Per cent.	Av. of duplicate samples %	Gain or loss %	Pounds per acre	Gain or loss Lbs. per acre
Edmonton	L.	Virgin	307	0-7	1.48				
"	"	"	312	"	--	1.480		31,080	
"	"	Cult. 20 yrs.	317	"	1.45				
"	"	" "	321	"	1.50	1.475	-.005	30,975	- 105
Parkland	L.	Virgin	137	0-6	1.44				
"	"	"	141	"	1.35	1.395		25,110	
"	"	Cult. 27 yrs.	145	"	1.42				
"	"	" "	149	"	1.34	1.380	-.015	24,840	- 270
Lethbridge	Si.L.	Virgin	105	0-5	1.44				
"	"	"	109	"	1.49	1.465		21,975	
"	"	Cult. Rot. U.	113	"	1.52				
"	"	" "	117	"	1.51	1.515	+.050	22,725	+ 750

Table XLII (Continued)

					Total K				
Location	Soil class	Virgin or cultivated	Sample No.	Depth in inches	Per cent.	Av. of duplicate samples %	Gain or loss %	Pounds per acre	Gain or loss Lbs. per acre
Gros Ventre	L.	Virgin	73	0-6	1.37				
"	"	"	77	"	1.46	1.415		25,470	
"	"	Cult. 20 yrs.	81	"	1.46				
"	"	" "	85	"	1.49	1.475	+.060	26,550	+1,080
Cavendish	F.S.L.	Virgin	41	0-5	1.57				
"	"	"	45	"	1.53	1.550		23,250	
"	"	Cult. 23 yrs.	49	"	1.52				
"	"	" "	53	"	1.49	1.505	-.045	22,575	-675
Breton	Si.L.	Virgin	173	0-7	1.51				
"	"	"	178	"	1.41	1.460		30,660	
"	"	Cult. Plot C 1	181	"	1.50				
"	"	" "	185	"	1.49	1.495	+.035	31,395	+735
"	"	Cult. Plot C 3	189	"	1.54				
"	"	" "	193	"	1.52	1.530	+.070	32,130	+1,470

DISCUSSION OF RESULTS

Nitrogen

From the data presented it has been concluded that significant losses of nitrogen have occurred in many cultivated western Canada prairie soils. Four main agencies are thought to be responsible for nitrogen losses. They are:

(1) Crop removal.

(2) Leaching.

(3) Erosion, both wind and water.

(4) Volatilization.

Crop Removal.

As previously mentioned the system employed in farming western Canada prairie soils is considered to be a very destructive one. Grain is grown and sold off the farm. Straw is too often burned instead of being returned to the land in some form. Very little attempt is made to grow legumes which are capable of securing part of their nitrogen from the air; something grain crops cannot do. Fertilizers are used by only a small proportion of the farmers, so that in the majority of cases the only return of nitrogen to the soil to compensate any loss is the few pounds per acre brought down in rain or snow, or the addition of small amounts of nitrogen by nitrogen-fixing bacteria. Continuous removal of

plant nutrients with no attempt made to return any, will in the end reduce initial fertility to a low level.

There is no record available of the crops removed from the various cultivated soils examined in this work except in the cases of the experimental stations. In these few cases the crop production has not been individually correlated with the loss of nitrogen. However, to arrive at a figure that will approximate the nitrogen removal in crops, average yields for each soil zone will be used. A figure has been worked out for the average number of years the soils in each zone have been cultivated, and to get a fair figure as to the actual number of crops removed, a fallow once in every three or four years is assumed. To simplify things it has also been assumed that the only crop grown has been wheat.

The black soils examined have been cultivated for an average of 27 years. Four hundred and sixty-two bushels of wheat have been produced over this period of time, if the average yearly yield has been 22 bushels with a fallow once every four years. A bushel of wheat extracts about two pounds of nitrogen in the grain and straw, and this represents a total loss if the straw is burned, which is a common practice. Therefore over 900 pounds of nitrogen per acre have been removed in crops from the black soils over a period of 27 years. The average loss from the surface 6 inches of the cultivated black soils was 1,775 pounds per acre. Thus over

800 pounds of nitrogen not accounted for in the crops was lost from the surface 6 inches, and the loss from the top foot amounted to nearly 1,500 pounds. Considerable losses must be due to some agency other than crop removal. Five cultivated fields out of nine examined have lost amounts varying from one half a ton to over three tons of nitrogen after crop removal has been subtracted.

The dark brown soils have been cultivated on the average for about 28 years, and with a fallow once every three years, about 18 crops have been actually taken off. Two hundred and fifty-two bushels of wheat have been removed if the average yield for the dark brown soils is 14 bushels. Thus about 500 pounds of nitrogen have been extracted in crops. The average loss from the surface 6 inches of cultivated soils in the dark brown belt is 1,145 pounds. If 500 pounds of this have been due to crops, then 645 pounds of nitrogen have been lost by some means other than crop removal.

If the brown soils, cultivated about 23 years, and fallowed every three years, produce 11 bushels of wheat per acre, the nitrogen removed in crops over this period of time will be 352 pounds per acre. The average total loss from the surface foot was about 900 pounds, so the loss of nitrogen due to agencies other than crop removal was about 550 pounds.

About 600 pounds per acre is the calculated nitrogen removal in grain and straw from the fields at Colinton and Grosmont. Considering the total nitrogen loss shown in Table

IX, Colinton has just about broken even and Grosmont must either have increased in nitrogen content or been more fertile than the sod to begin with.

The gray soils have been cultivated for an average of about 13 years, and if fallowed one year in four, 10 crops have been taken off. The average yield from gray soils is quite low, around 10 bushels per acre. Ten crops of 10 bushels per acre of wheat means an extraction of 200 pounds of nitrogen per acre. Thus the loss from the top foot of gray wooded soils, after nitrogen removal in crops has been subtracted, was almost 700 pounds of nitrogen per acre.

Therefore approximately one-third to one-half of the average nitrogen loss from the surface of cultivated fields in the black, dark brown, brown and gray soils was due to crop removal.

Losses of Nitrogen Due to Leaching.

Alberta soils are capable of producing considerable amounts of nitrate nitrogen, as nitrification figures have previously shown (Table XLI). However, loss of nitrogen in the nitrate form is not believed to take place to any extent in most Alberta soils. Precipitation is not great, evaporation is quite high, and the nearness of the lime accumulation to the surface is an indication of the shallowness of leaching. A movement of nitrate to somewhat lower levels may occur.

However, a gain of nitrogen in lower depths was not always found, so most of the increase when such occurred was more likely due to soil variation.

Losses of Nitrogen Due to Wind and Water Erosion.

Some soil drifting has taken place, especially throughout south-central and southern Alberta and Saskatchewan, the degree of drifting varying with the topography, soil class and cropping system. In some sections wind erosion has become very serious. When the samples were obtained great care was taken to avoid fields that had obviously been subject to drifting, but it is possible that drifting on some of these fields may have occurred to a small degree in the past. A loss of one inch of surface soil removes 300,000 pounds of the richest portion. A soil of .2 per cent. nitrogen would lose 600 pounds of nitrogen per acre if the top inch of soil were removed by blowing. Some of the loss found in soil samples from the dark brown and brown zones, particularly, may have been due to soil drifting. Alway (2) found losses of nitrogen in cultivated soils and attributed such losses to either washing or blowing away of the surface soil, that is, by physical agencies rather than by chemical or biochemical action.

Water erosion is probably a contributing factor to soil deterioration in Alberta and Saskatchewan, but it is difficult to estimate the extent of this deterioration.

However, a part of nitrogen is [illegible] [illegible] [illegible] [illegible] [illegible], as much as the [illegible] [illegible] [illegible] [illegible] [illegible] to the soil [illegible].

Losses of nitrogen due to [illegible] [illegible] [illegible] [illegible].

Some soil [illegible] [illegible] [illegible], [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] the degree of [illegible] [illegible] [illegible] the [illegible], [illegible] [illegible] [illegible] [illegible]. [illegible].

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] difficult to [illegible] [illegible] [illegible] [illegible] [illegible].

Losses from water erosion are not as serious as losses from wind erosion, except in isolated cases.

Loss of Nitrogen in Some Volatile Form.

No work has been done in this investigation to determine whether or not it is possible that nitrogen is lost from the soil in some volatile form. Furthermore no direct experimental evidence has been produced, amongst the papers reviewed, that proves definitely a nitrogen loss in such a manner. Gainey, Sewell and Latshaw (8); Lyon (16); Wright (39); Lyon and Bizzell (17) suggest the loss of nitrogen through volatilization.

Lyon (16) says that the loss of gaseous nitrogen may cause a greater removal of nitrogen from a soil than occurs through absorption by crop plants. The conditions that favor a large loss of this kind are:

(1) Tilling or stirring the soil in any way.
(2) Absence of plant growth.
(3) High nitrogen content of a soil.
(4) Applications of large quantities of nitrogenous manures.

If tilling or stirring the soil and absence of plant growth are conducive to nitrogen losses, fallowing as practiced in the prairies of western Canada would be an important factor contributing to nitrogen losses.

Buswell and Neave (5) have this to say: "It seems

undeniable that certain bacterial types under suitable conditions can occasion nitrogen losses either as the gas or its oxides. These conditions are usually regarded as the presence of nitrate, the presence of specific organisms, excess of readily assimilable plant food, and limited access of oxygen. All these conditions are rarely met with at one time in a soil".

The large part of the decreases in soil nitrogen found in Alberta and Saskatchewan, other than those caused by crop removal, are occasioned by either soil drifting, water erosion or volatilization. In some of the black and gray soils where drifting has not been a major factor the only explanation left for nitrogen loss is by its volatilization in some unknown form by leaching or water erosion.

Soil variability may have accentuated some of the losses from the cultivated soils, just as it may have been responsible for some of the gains found.

Organic Carbon

Organic matter losses have been proportionately greater than nitrogen losses. Considering the type of management followed large losses of organic matter are to be expected. Little effort is made to maintain this important soil constituent in western Canada prairie soils. Conditions are made very suitable for vigorous bacterial action by

tilling the soil and thoroughly aerating it. A fallow conserves the moisture and during the warm summer months decomposition of organic matter can proceed under almost ideal conditions. Organic matter is used by the bacteria for energy purposes and carbon is liberated as CO_2.

Organic matter must be broken up to supply nitrogen as nitrates to a growing crop. It was calculated before that 900 pounds of nitrogen per acre has been extracted from cultivated black soils to produce about 450 bushels of wheat. A general factor used to calculate organic matter from nitrogen content, is 20. Then the amount of organic matter required to liberate 900 pounds of nitrogen is about 18,000 pounds per acre. On the average 61,000 pounds of organic matter have been lost from the surface foot of cultivated black soils, or about 2½ times as much as was needed to supply 900 pounds of nitrogen per acre.

Losses are apt to be excessive at first and continue until the most readily decomposable material is used up. When the organic matter becomes more resistant, then bacterial action will slow down.

Some leaching down of organic matter may have occurred in some of the samples and explain in part the large increases found in lower depths (Edmonton, Melfort). It is felt, however, that most of the increase can be attributed to soil variability.

The various beneficial aspects of soil organic matter need not be enlarged upon here, since the importance of organic

matter in the soil is well known. In view of this importance excessive loss of organic matter is going to lead eventually to serious soil deterioration.

Carbon to Nitrogen Ratios

The C:N ratios presented in Table XXIV offer further evidence that organic carbon has been lost at a greater rate than nitrogen. The general narrowing of the ratios in the cultivated samples indicate this.

Since the average loss of nitrogen from the gray soils is very close to that found from the brown soils, it might be expected that relative losses of organic carbon would be similar. However, the loss of carbon from the gray soils is about the same as that from the dark brown soils. The explanation for this may lie in the extremely wide C:N ratio of virgin gray wooded soils, about 20:1. It would be expected that more organic matter would have to be acted upon to liberate the same amount of nitrogen from the gray soils as from the brown soils in which the C:N ratio is about 12.5:1.

An interesting feature of the C:N ratios of the gray soils is the large proportion of carbon to nitrogen, about 20:1. The organic matter contains some very coarse and woody material, not unnatural perhaps when it is remembered that it is laid down under trees and bush. Quite moist and sometimes slightly acid conditions prevail, and under tree

growth this is not conducive to a build up of organic matter.

Total Phosphorus

A loss of total phosphorus must occur in the soil as a result of crop removal. If a 30 bushel crop of wheat contains about 10 pounds of phosphorus in the grain and straw, the removal of phosphorus in the estimated crops produced on the fields examined from the various soil zones should be as follows: black soils 154 pounds; dark brown soils 84 pounds; brown soils 57 pounds and gray soils 33 pounds. The average loss of phosphorus from the surface 6 inches of cultivated black soils was 223 pounds per acre, of which an estimated 154 pounds have been removed in crops, leaving about 70 pounds to be accounted for in some other manner. No loss of phosphorus occurred in the three dark brown soils examined. The losses from three out of six cultivated brown soils have been larger than the amount removed in crops. The other three locations in this zone showed more phosphorus than the sod. Four out of five gray soils have lost more phosphorus from the surface 6 inches than can be accounted for by crop removal. The total loss is considerably greater than the crop removal.

Phosphorus is generally considered to exist in the soil in a form which is very insoluble. In high lime soils, particularly, most of the phosphorus is tied up with the calcium as $Ca_3(PO_4)_2$ which is not soluble in water. It is

likely that any losses of phosphorus through leaching processes are of a very small order. If leaching waters did carry down much phosphorus lower horizons of the virgin black soils, for instance, should contain more phosphorus than the surface. An examination of Table I shows that such is not the case.

Decreases of phosphorus that are greater than can be accounted for by crop removal might be said to be due to soil drifting were it not for the fact that there is no reason to believe that drifting has been more serious at locations where losses were shown than at locations where no loss could be detected. Natural soil variability cannot be disregarded when considering losses of phosphorus. Furthermore it is difficult to account for the increase of phosphorus content where such was found in cultivated soils. About the only recourse is to attribute it also to soil variability.

Easily Soluble Phosphorus

Insofar as conclusions can be drawn from the analyses of a few samples from each zone, the cultivated black, dark brown, and gray soils, show more increases of easily soluble phosphorus than decreases, while four out of six cultivated brown soils have less easily soluble phosphorus than the sod. Dorman (7) found available phosphorus to be very low in both virgin and cultivated soils, and no consistent difference in

favor of one or the other. Stewart (28) found great dissimilarities in the water soluble phosphate content of different soils throughout the season, but in any one soil the amount was practically constant in both the cropped and uncropped plot. No significant difference in water soluble phosphorus was reported by Millar (18) and Powers and Lewis (19). No explanation can be given for the increases or decreases of easily soluble phosphorus in cultivated soils unless it is due to soil variability. No work was reviewed which reported the various effects of different crops, or fallow, or moisture conditions on the easily soluble phosphorus content of the soil.

Nitrification

Nitrification figures show that cultivated fields from all zones are capable of producing considerable amounts of nitrate nitrogen, even in those cases in which large losses of nitrogen and organic matter were found.

Five out of six black sod samples showed greater nitrifying power than the cultivated samples at the end of the incubation period. The loss of nitrogen from the surface 6 inches of these same cultivated fields varied from 1,582 to 3,222 pounds per acre and the loss of organic carbon varied from 12 tons to 27 tons. These large losses may have had a

tendency to reduce the nitrate supplying power of the cultivated soil. The only location in the black soils at which the cultivated field shows a higher nitrification rate than the sod is at Lacombe. The loss of nitrogen here was only 1,044 pounds in the surface and the organic matter loss less than one half of the 12 ton loss found at Vegreville.

In most instances the cultivated soils from the dark brown and brown zones have exceeded the sod in nitrifying ability. The cultivated field at Gros Ventre lost almost 2 tons of nitrogen and over 15 tons of organic carbon. Such a reduction might account for the poorer nitrate supplying power compared to the virgin sod. Contrary to what was found at Gros Ventre, losses of nitrogen and organic matter from Rotation U at Lethbridge were not large, yet the nearby virgin soil possesses greater nitrifying power than the cultivated plot.

It was not until several weeks after incubation started that virgin gray wooded samples produced appreciable amounts of nitrate nitrogen. According to Russel (20) and others the nitrogen of soil organic matter can appear as nitrate only if it exceeds a certain critical amount relative to carbon, and when the proportion of carbon is greater, the nitrogen remains as complex protein. This critical ratio is usually twelve or less of carbon to one of nitrogen, but in these Alberta gray soils nitrates accumulated in spite of a wider carbon to nitrogen ratio. If an excess of organic

matter is present and is readily decomposable, under optimum conditions microbial numbers will increase tremendously. Organic matter is broken down to provide a source of energy and nitrogen is liberated. However, due to the rapid growth in microbial numbers and hence their increased requirement of nitrogen for building up protein in their own bodies, little nitrogen is made available to the plant. As the C:N ratio narrows, nitrogen as nitrate will tend to accumulate. The C:N ratio of the virgin and cultivated gray soils is quite wide. The ratio of the virgin soil is quite a bit wider than that of the cultivated soil, and this may account for the low nitrate content shown early in the incubation period.

There is the possibility that if the incubation period had been extended the virgin soils might have eventually equalled and even surpassed the cultivated soil in nitrifying power.

Ups and downs in nitrate curves are a common occurrence in nitrification studies. Total and relative numbers of different species of bacteria, fungi, etc., fluctuate with conditions under which they occur and with this fluctuation the parts per million of nitrate nitrogen is apt to increase and decrease.

Potassium

The wheat crop requirements of potassium are between

those for nitrogen and phosphorus. A 30 bushel crop of wheat requires about 35 pounds of potassium. Using the average yield figures for each soil zone employed before, the amounts of potassium extracted from the various zones are as follows: Black 539 pounds; dark brown 294 pounds; brown 208 pounds; and gray 116 pounds per acre.

The losses of potassium at Edmonton and Parkland were much less than the probable crop extraction, while the loss at Cavendish was about three times what might be expected.

The potassium content of a soil may be lowered in four main ways; viz, crop removal, leaching, water erosion, and soil drifting. Crop removal has not been great in any zone when the total amount in the soil is considered. Leaching losses are negligible since the climate does not favor such. Serious soil drifting could cause large losses from the surface. However, none of these factors have been very active in causing potassium losses in the samples analyzed, except possibly at Cavendish.

Increases of potassium in the surface could be due to roots bringing this element to the surface and depositing it there as they decay. The most likely reason for increases, however, is soil variability.

SUMMARY

Nitrogen, carbon, total phosphorus, easily soluble phosphorus and potassium have been determined on some virgin and cultivated western Canada prairie soils. Nitrification studies have been made as well on some surface horizons. Carbon to nitrogen ratios were computed from per cent. carbon and per cent. nitrogen figures.

Nitrogen. Twenty-six out of thirty-four cultivated fields in widely scattered points in Alberta and Saskatchewan have lost nitrogen in amounts varying from 96 to 7,128 pounds per acre.

The surface 6 inches of cultivated black, dark brown, brown, and gray soils have lost on the average 1,775, 1,145, 765 and 723 pounds of nitrogen per acre respectively. This amounts to decreases of 18 per cent., 2~~5~~2 per cent., 20 per cent. and 35 per cent. of the original nitrogen content as measured by the virgin sod.

The only decrease of any magnitude that occurred in the 6 to 12 inch depth was in the black zone, a decrease of 602 pounds or 11 per cent. of the original nitrogen.

It was calculated that approximately one-third to one-half of the average nitrogen loss from the surface of cultivated fields in the black, dark brown, brown, and gray soils was due to crop removal.

A straight grain and fallow system has not maintained the nitrogen content of western Canada prairie soils.

Organic Matter. Twenty-nine out of thirty-four cultivated fields examined show losses of organic matter in amounts varying from about 1 ton to over 78 tons per acre in the depth analyzed.

The surface 6 inches of cultivated black, dark brown, brown, and gray soils have apparently lost 45,903; 29,622; 22,550; and 29,998 pounds of organic matter per acre respectively on the average. These decreases amount to 21 per cent., 26 per cent., 27 per cent., and 42 per cent. of the original organic matter content.

The 6 to 12 inch depth of the black, dark brown, brown, and gray soils have apparently lost an average of 15,185; 3,746; 5,719; and 5,524 pounds of organic matter per acre. In the same order the per cent. loss was 21 per cent., 11 per cent., 11 per cent. and 17 per cent.

A general loss or gain of organic matter at depths below 12 inches in the various zones has not been established.

A straight grain and fallow system has not maintained the organic matter content of the cultivated prairie soils of western Canada.

C:N Ratios. Cultivation has resulted in a narrower C:N ratio in the surface horizon of twenty-seven out of thirty-four cultivated fields, in the subsurface of twenty-two out

of ~~twenty~~ thirty-three fields, and in seven out of ten subsoils.

The C:N ratio narrows with the depth of both cultivated and virgin soils.

Gray surface soils have a C:N ratio of about 20:1. Other soils have a narrower ratio varying from about 10 to 13 units of carbon to 1 of nitrogen.

Total Phosphorus. The cultivated black soil samples were the only ones to show a significant loss of phosphorus in any 6 inch depth as compared to the sod, and this loss was 223 pounds per acre or 10 per cent. of the original content from the surface 6 inches.

Considering total losses and gains from cultivated soils to the depth analyzed, the black and brown soils showed an equal number of losses and gains, the gray soils more losses than gains, and the three dark brown soils all gains. However, because of the small number of samples analyzed and the small order of some of the increases or decreases found, it has not been definitely established that phosphorus is lost or gained in any soil zone.

Easily Soluble Phosphorus. More easily soluble phosphorus was found in the cultivated black and dark brown soils, less in the cultivated brown soils, and neither more nor less in the gray soils, but some of the gains and losses were very small, and with a lack of uniformity in the results from the few samples analyzed, a definite statement as to

general gains or losses in the various zones cannot be made.

Nitrification. After three months' incubation virgin soils from the black zone possessed greater nitrifying power than did the cultivated soils.

Cultivated soils from the dark brown, brown, and gray zones generally contained more nitrate nitrogen than the sod after about three months' incubation.

Nitrates did not accumulate for several weeks in incubated virgin gray wooded soil samples, but increased later.

Nitrates accumulate in gray, wooded soils in spite of their wide C:N ratio of about 20:1.

Potassium. An analysis of virgin and cultivated samples from six locations has not established a gain or loss of potassium as a result of cultivation and cropping.

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